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THE JOURNAL

OF

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

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The Society as a body is not responsible for the statements of facts or opinions advanced in papers or discussions. C55

THE JOURNAL

OF

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

VOL. 33 MARCH 1911 NUMBER 3

THE SPRING MEETING

The 63d meeting of the Society will be held in Pittsburgh, Pa., from May 30 to June 2, 1911. Not since 1884 has a meeting of the Society been held in that city, which was for that reason given first choice by the Council, although much gratification has been felt over the numerous invitations received from different parts of the country. An effort was made to place the date earlier in the month of May in order to render it convenient for the large number of members connected with the universities and colleges, but this proved impossible because of conventions of other societies already arranged for.

An Executive Committee of members of the Society in Pittsburgh has been chosen, with E. M. Herr, Chairman, and E. K. Hiles, Secretary, and the following members, each serving as chairman of a subcommittee: George Mesta, Committee on Finance; John M. Tate, Committee on Entertainment; Chester B. Albree, Committee on Hotels; Morris Knowles, Committee on Printing; D. F. Crawford, Committee on Transportation. A Ladies' Committee will as usual care for the entertainment of the visiting ladies.

The headquarters of the meeting have not yet been chosen but members who desire to make early application for hotel accommodations should write to the chairman of the Committee on Hotels. These will be given careful attention in the order of their receipt.

MONTHLY MEETINGS

NEW YORK MEETING, MARCH 10

A meeting of the Society in New York will be held in the Engineering, Societies Building, on Friday evening, March 01, in coöperation with the American Institute of Electrical Engineers. The subject of the meeting will be The Cost of Industrial Power. Papers will be presented on power costs by members of both organizations and those having intimate knowledge of the cost of producing power in both central or isolated and industrial plants are expected to participate in the discussion.

SAN FRANCISCO MEETING, MARCH 10

At a meeting of the Society in San Francisco, March 10, Pacific Coast Practice in the Use of Crude Petroleum will be the subject of a general discussion. This topic was considered at the meeting of the Society in San Francisco on December 16, when eight contributions covering various phases, were presented. These papers and the topic in general will be considered at the coming meeting.

BOSTON MEETING, MARCH 17

A meeting of the Society will be held in Boston on March 17. The paper by Wm. F. Uhl, Speed Regulation in Hydro-Electric Plants, will be discussed. The Boston Section of the American Institute of Electrical Engineers and the Boston Society of Civil Engineers have been invited to attend.

NEW YORK MEETING, FEBRUARY 14

A meeting of the Society in New York was held on February 14 in the Engineering Societies Building, with an attendance of 81. The topic of the evening, The Mechanical Engineer and the Prevention of Accidents, was presented by John Calder of Ilion, N. Y., who gave in abstract his paper on the subject, analyzing the causes of accident and citing various methods for guarding equipment and processes, drawn chiefly from his own experience in plant management. The

paper was discussed by F. R. Hutton, representing the American Museum of Safety; Byron Cummings, representing the Ocean Accident and Guarantee Corporation: Luther D. Burlingame of the Brown and Sharpe Manufacturing Company; M. W. Alexander of the General Electric Company, Lynn, Mass., who has served as a Commissioner of the State of Massachusetts in working out compensation laws; L. B. Alford, Engineering Editor of the American Machinist; David Van Schaak of the Aetna Insurance Company of Hartford, Conn. Written discussions were contributed by Oberlin Smith, President of the Ferracute Machine Company, Bridgeton, N. J., and Alexander Taylor, of the Westinghouse Electric and Manufacturing Company, East Pittsburg, Pa. Lantern slides were used by Mr. Calder, Professor Hutton and Mr. Burlingame to illustrate their remarks.

At the close of the meeting a large number of those present availed themselves of the invitation extended by the American Museum of Safety to inspect their exhibit on the sixth floor. The museum contains many models of safeguarding machines and operations, in particular a very complete collection of those used by the United States Steel Corporation, all of which were of interest to the visitors.

BOSTON MEETING, FEBRUARY 17

The Society, together with the Boston Society of Civil Engineers coöperated on February 17 in a meeting of the Boston Section of the American Institute of Electrical Engineers, which was held in the auditorium of the Edison Electric Illuminating Company. A paper entitled Economic Limitations to Aggregations of Power Systems was presented by R. A. Philip, Assoc. Mem.A.I.E.E., of the Stone and Webster Engineering Corporation, covering a study of the factors governing the extension and growth in transmission systems and their interconnection, assuming constant potential conditions throughout a system. It was discussed by Herman T. Wilcox of the Lowell Electric Corporation; C. A. Adams of Harvard University; Mr. Ekein of the Stone and Webster Engineering Corporation; A. E. Kennelly of Harvard University; E. N. Lake of the Stone and Webster Engineering Corporation; and F. E. Frothingham, Mem.Am.Soc. M.E., of Perry, Coffin and Burr. About 180 were in attendance. This paper was published in the February issue of the Proceedings of the American Institute of Electrical Engineers.

ENGINEERS' DINNER AT BOSTON

An engineers' dinner, attended by more than 400 representatives of the profession as a whole, similar in character to that of a year ago, was given in Boston on the evening of January 31 in the Hotel Somerset. The arrangements for the gathering were in charge of the Boston Section of the American Institute of Electrical Engineers, the Boston Society of Civil Engineers and The American Society of Mechanical Engineers coöperating. John F. Vaughan, Chairman of the Boston Section of the American Institute of Electrical Engineers, presided and called upon Prof. Ira N. Hollis, Mem.Am.Soc.M.E., to give the present status of plans for an engineering building, as formulated by the committee appointed at the dinner of 1910. Professor Hollis reported that as a result of a number of meetings it had seemed best to securea site in the center of Boston, and that the committee had already passed upon two or three locations. The cost of an adequate building, he said, would be between $30,000 and $50,000.

J. J. Carty, Mem.A.I.E.E., chief engineer of the American Telephone and Telegraph Company, who represented the American Institute of Electrical Engineers in the absence of President Jackson, spoke of the part of the engineer in the revolution in conditions of life which is taking place in America, and of the need of his entrance into public affairs to a greater extent than heretofore.

Mr. Carty was followed by Col. E. D. Meier, President Am.Soc. M.E., who spoke of the debt of America to New England. He said that, as a new nation, we were obliged to borrow from the older nations of Europe, but that after they had given us the science it was the American mechanic and the American engineer who made use of the facts of those sciences and brought them into practical shape for service to men. It was a Yankee, Benjamin Thomson, who demonstrated experimentally the mechanical equivalent of heat at Munich. It was a New Englander, Joseph Francis, who invented and built the first internal discharge turbine and realized an economy which has not yet been excelled. The engineers and machine builders of Europe had been improving the steam engine for nearly half a century without making much progress in its economy until a Yankee, George H. Corliss, showed them the way by his wonderful

discovery, making possible the real economy of the steam engine. In the early days of steam navigation, it was Yankee clippers built in our shipyards here which set records the early Atlantic steamers were unable to break. The first industry to expand, the textile, derived its possibilities from the invention of the cotton gin by Whitney; and when steam was needed to help out water power, Corliss and those who followed him stepped into the breach. The production of anything in quantities, the actual manufacture of machinery, was inaugurated in America. Muskets and rifles had been made in Europe for many years, but it was at the Springfield armory that they were first made by the thousand, by making all the parts interchangeable—an American and a Yankee idea. The mechanical genius of the nation was equal to the difficulties of building railroads, which on account of the vast distances, great ranges of mountains, immense streams, were much greater here than in Europe, and while the first railroads were crude, there were today none in the world which can compete with some of those in America. Men like Faraday, Volta, Ohm and Siemens were leaders in the science of electricity; but it took men like Thomson, Edison and Field to develop it into the practical uses of mankind. The first submarine cable was the project of Americans and was laid by them. He voiced in conclusion his hearty approval of such gatherings of the profession as a whole and said that while none of us as individuals could know more than a little, as a body we were possessed of much knowledge.

Henry F. Bryant, President of the Boston Society of Civil Engineers, the oldest engineering society in America, followed Colonel Meier and further emphasized the great need of coöperation in the different branches of engineering, adding his hope that the engineering building in Boston would soon cease to be theory and become a practical reality.

The speaker of the evening, Prof. Elihu Thomson, Mem.A.I.E.E., of Lynn, Mass., was introduced by President Richard C. MacLaurin of the Massachusetts Institute of Technology.

Professor Thomson said that while electrical engineering is the youngest of the engineering branches, we are finding that the universe is really and fundamentally electrical—that matter itself is composed of electrical corpuscles, and that the forces that act on matter, inertia, momentum, gravitation, etc., are in their very essence electrical; so that we are occupying the universe theoretically if not practically. In the progress of engineering. we have seen in the past ten, fifteen or twenty years very great changes and advances. We are living indeed in what we might call the scientific age. Formerly men had to

do their work by empirical methods and were obliged to do a great deal of guessing. They had to work by a sort of intuition, particularly in the early days of electrical engineering. Even now we have not by any means gotten over it, but need more and more information. The pure science of this day is the applied science of the day far in advance. "When Davy put the batteries together and the two little carbon points, one against the other, and then drew them apart, he formed what he called an arch of light. It was the arc of today. Davy in writing his description of it said: 'It is a truly gorgeous experiment.' That was all. But just think what the arc means in electrical engineering."

Emphasizing the need of greater support of our technical schools, he said: "I look forward to the time when the technical man, the well-informed scientific technically trained man, will be a factor of far greater consequence in the community than he is today. I look forward to the time when no business man will enter upon an enterprise without first having the opinion of one or more well-informed technical men. How much money is thrown away in all sorts of worthless ventures, when, if the business man always had it in mind to say, 'There must be somebody who knows about this a great deal better than I do and I will consult him,' how much wastage would be saved. How many enterprises which are merely on paper would be downed from the start. How many ways of gambling, so to speak, would be stopped in their inception.

If we look into the future far enough we will see that what has come about in reference to pure food will come about concerning these other things. It will be made a misdemeanor and something that cannot legally be done, to foist upon the public schemes which have not the proper endorsement of technical men; and the technical man will then come into his own.

I think a gathering of this kind, a union of engineers, is of great value in bringing out the views of engineers themselves; for let a body of engineers, one dealing with one sort of problems and another with another sort, talk together, and the result is undoubtedly very highly educational. A man goes away from a meeting of that sort with a broader and more comprehensive view of the work that is being done in the world; and a broad man is, of course, a valuable man because he is always able to tell in what direction information should be looked for and who are the best men to furnish it."

Prof. Arthur E. Kennelly, Mem.A.I.E.E., acted as toastmaster and added much to the occasion by his apt introductions. The evening concluded with a rising vote of thanks to the speakers.

LETTER FROM ADMIRAL MELVILLE

The following letter has been received from Rear-Admiral George W. Melville, Honorary Member of the Society, in reply to a elegram of congratulation from the Council on his seventieth birthday.

Philadelphia, January 17, 1911

COL. E. D. MEIER, PRESIDENT,
THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS,
29 West 39th Street, New York City, N. Y.

My dear Colonel:

I have been so busy since my seventieth birthday on the 10th inst., that I am just taking up the pleasant duty of acknowledging the kind words of congratulation which have been received from my friends in such large number.

One of the congratulatory messages which I prize most highly is your telegram of the 10th inst., transmitting the good wishes of the Council of the Society, which was in session that day.

May I ask you to convey to the members of the Council my sincere thanks for their remembrance, which is only another of the courtesies and acts of appreciation which the Society has shown me during many years.

Believe me, with kindest regards,

Your sincere friend,

(*Signed*) GEO. W. MELVILLE

STUDENT BRANCHES

ARMOUR INSTITUTE

The Armour Student Branch held a regular meeting, January 4, 1911, at which Chas. E. Sargent, Mem. Am. Soc M. E., read a paper on Gas Engines, illustrating by lantern slides various types of engines and working parts. At the meeting on February 1, Prof. A. J. Anderson gave an address on Railway Draft Gears which was also illustrated by slides.

BROOKLYN POLYTECHNIC INSTITUTE

On January 7 at a meeting of the Polytechnic Institute Student Branch F. R. Low, Mem. Am. Soc. M. E., Editor of Power, gave an interesting illustrated lecture on Entropy, following the business of the evening. On February 4, Prof. W. D. Ennis, Mem. Am. Soc. M. E., gave an instructive talk on Flying Machines.

CORNELL UNIVERSITY

At the first meeting of the Sibley College Student Branch on October 21, Professor Ford gave an impromptu talk on The Field of the Technical Graduate. On November 18, D. S. Wegg, Jr., Jun. Am. Soc. M. E., was elected corresponding secretary in place of C. F. Hirshfeld, resigned. C. C. Trump (1911) presented a paper on the Humphrey Gas Pump which was illustrated by lantern slides. The organization expected to have with them on December 15 Prof. John E. Sweet, Hon. Mem. Am. Soc. M. E., but he was unable to be present and Prof. D. S. Kimball, Mem. Am. Soc. M. E., kindly volunteered to take his place. Professor Kimball spoke upon the Modernization of the Power Plant at the United States Hospital for the Insane at Washington, D. C.

LELAND STANFORD JUNIOR UNIVERSITY

At the meeting of the Leland Stanford Junior University Student Branch on February 2, F. O. Ellenwood addressed the members on

Gas Engine Ignition. This subject was further discussed by Prof. Wm. F. Durand, Mem.Am.Soc.M.E., and Prof. S. B. Charters, Jr., both of the university.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

At the meeting of the Mechanical Engineering Society of the Massachusetts Institute of Technology, on February 10, Ralph E. Flanders, Mem.Am.Soc.M.E., addressed the members on the subject of Gear Cutting Machines, dividing it into its important branches and discussing each branch in detail. The lecture was illustrated by lantern slides.

The annual dinner and meeting of the society are being planned for the second week in March and will probably be held at the Boston City Club. Among the guests and speakers will be Prof. Gaetano Lanza, Mem.Am.Soc.M.E., Prof. Edw. F. Miller, Mem.Am.Soc. M.E., Prof. Ira N. Hollis, Mem.Am.Soc.M.E., and I. E. Moultrop, Mem.Am.Soc.M.E.

PENNSYLVANIA STATE COLLEGE

On February 7, at the meeting of the Pennsylvania State College Student Branch, a paper was presented by H. E. Davis (1910), on Methods of Welding Aluminum, dealing especially with soldering, welding with hydrogen, and with oxy-acetylene.

PURDUE UNIVERSITY

At a meeting of the Purdue Student Branch, February 9, the following officers were elected: L. Jones, Chairman; C. Abbott, Vice-Chairman; H. E. Sproull, Corresponding Secretary; A. Harter, Secretary; and C. E. Trotter, Treasurer. After this business had been transacted, W. A. Hanley (1911) gave an interesting talk on The Relation of Flue Gases to the Efficiency of Boilers, based on experience gained during the summer of 1910, while in the employ of the American Gas and Electric Company.

UNIVERSITY OF CINCINNATI

At a meeting of the University of Cincinnati Student Branch held on January 27 a lecture was given by Geo. K. Elliott, of the

Lunkenheimer Company, on Industrial Alloys, illustrated with microphotographic slides. A luncheon followed the address.

UNIVERSITY OF KANSAS

The second annual meeting of the Kansas University Student Branch was held in Lawrence on January 5 in the assembly hall of the main engineering building and brought out many interested visitors and students. The program included papers on Some Recent Improvements on Locomotive Boiler Construction, by Wm. J. Leighty of Topeka, Kansas; Results of a 7 hr. Test on an Air-Lift Pumping Outfit, by John D. Farrell (1911) and Thomas A. Purton (1911); Results of a 2-hr. Test of an 1100-h.p. Gas Engine, by Wilbur H. Judy, Chairman of the Student Branch. Two addresses were made, one on Scientific Management, by Prof. H. Wade Hibbard, Mem. Am. Soc. M. E., of the University of Missouri; and the other on Aeronautics, by Capt. Charles DeForest Chandler, U. S. A. The latter was illustrated by a number of instructive lantern slides. A banquet was given in the evening in honor of the guests, Prof. P. F. Walker, Mem. Am. Soc. M. E., acting as toastmaster.

On February 9, a paper on Modern Installation for Power and Refrigeration in a Packing Plant was presented by M. C. Conley. The topical discussion on Smoke Abatement was also considered at this time.

UNIVERSITY OF MAINE

At a meeting of the University of Maine Student Branch, held on January 5, a paper upon the Unidirectional Flow Steam Engine was presented by W. W. Hatch (1911). The characteristic features of the engine were described and the factors affecting the engine's efficiency were well pointed out, lantern slides being used by way of illustration.

UNIVERSITY OF MISSOURI

The following officers of the University of Missouri Student Branch were elected at the meeting of January 19: F. T. Kennedy (1910), president; G. D. Mitchell (1910), secretary and treasurer; Osmer N. Edgar (1910), corresponding secretary.

UNIVERSITY OF NEBRASKA

At a joint meeting of the Student Branch of the Society in the University of Nebraska with the Student Section of the American Institute of Electrical Engineers on January 19 plans were formulated for a trip to Omaha in the Spring, to inspect the shops and power-houses of the city. Two papers were presented: A Plea for the Draftsman, by Prof. Philip K. Slaymaker, and Ventilating Engineering, by Prof. L. A. Scipio. A second joint meeting of the two organizations was held on February 9, at which Prof. C. R. Richards, Mem.Am.Soc.M.E., read a paper on Refrigerating Engineering.

UNIVERSITY OF WISCONSIN

The University of Wisconsin Student Branch held a joint meeting with the Madison Branch of the American Institute of Electrical Engineers on January 17. A. L. Goddard, Mem. Am. Soc. M. E., presented a paper upon Machine Tool Motor Drives, speaking of various applications of constant speed motors to lathes, planers, boring and drilling machines where variable speed was obtained by means of step pulleys and the weight of the motor assisted in keeping the proper tension in the belts. This was discussed by A. G. Christie, Assoc. Am. Soc. M. E., and H. B. Sanford. They were followed by A. Hirsch who gave a talk upon Alcohol Distillation, in which he treated of differential condensation in distillation and rectification of alcohol and water mixtures, and showed how this method was realized through research in the laboratory and applied commercially so as to reduce the difficulty of getting a high alcohol percentage.

YALE UNIVERSITY

Charles Whiting Baker, Mem. Am. Soc. M. E., Editor of Engineering News, delivered an illustrated lecture on The Panama Canal at the meeting of the Yale Mechanical Engineers Club on January 24. This was followed by an informal discussion.

REPORTS

MEETING OF THE COUNCIL

A meeting of the Council was held on February 14, in the rooms of the Society. There were present: E. D. Meier, President, presiding, C. W. Baker, James Hartness, Charles Wallace Hunt, F. R. Hutton, E. B. Katte, I. E. Moultrop, Jesse M. Smith, F. W. Taylor, H. G. Reist, Alex. C. Humphreys, and the Secretary. Regrets were received from D. F. Crawford, George M. Brill, H. L. Gantt, H. H. Vaughan, W. F. M. Goss, and Stanley G. Flagg, Jr.

The President reported that as a result of extended discussion at a previous meeting of the Council, the Executive Committee had held a meeting to consider a change in present policies, to provide for the conditions of the Society's development. As a result of this meeting a special committee has been appointed, consisting of three members of the Executive Committee, the Chairman of the Committee on Meetings and of the Publication Committee, and the President and Secretary. The Secretary read the report, including suggested changes in the Rules.

Voted: To receive the report, but to defer action until the next meeting of the Council.

Voted: That the Secretary be directed to send a copy of the edited report together with the draft of the proposed amendments to the Rules, to the members of the Council, the Publication Committee, Committee on Meetings, Committee on Constitution and By-Laws, and to the secretaries of the local committees and Gas Power Section for their opinion and comment, the report then to be referred back to the Special Committee for consideration and report as a special order of business for the Council Meeting of March 10.

Voted: To refer to the Committee on Constitution and By-Laws the letter of the Third Assistant Postmaster-General, together with the recommendations of the Publication Committee, and that the former committee proceed to prepare draft and report to the Council proposed changes in the Constitution and By-Laws of the Society to comply with the law.

Voted: That the Publication Committee be requested to investigate the subject of reducing the weight of The Journal and report to the Council.

Voted: That the previous decision of the Council adverse to the use of emblems by Student Branches be rescinded.

Voted: That the requests for such emblems be referred to the Committee on Student Branches to consider and report suggestions for approval by the Council.

The Secretary reported the following deaths: J. B. Edson, J. O. Norbom, J. W. Seaver, L. R. Alberger, Chas. H. Morgan.

Voted: To confirm appointment by the President of the following Honorary Vice-Presidents to attend the funeral of Mr. Morgan: Geo. I. Alden, F. H. Daniels, Charles M. Allen, M. P. Higgins, Geo. I. Rockwood, C. J. H. Woodbury.

Voted: To accept the resignations of J. H. Kendall, and W. H. Horton.

Voted: To approve the action of the Executive Committee in selecting Pittsburg for the Spring Meeting of the Society, May 30–June 2.

The suggestion was approved that in the future the decision regarding time and place for the Spring Meetings be made annually at the preceding Spring Meeting.

The Secretary read the minutes of January 30, 1911, of the Committee on Public Relations containing the recommendations of that Committee to the Council.

Voted: That the Committee on Public Relations be requested to confer with the representatives of other societies having the matter of Licensing Engineers in hand, with the hope of doing the utmost to secure concerted action.

Voted: That to conform to other standing committees the terms of office of the members of the Committee on Public Relations be as follows: Robert W. Hunt, one year; D. C. Jackson, two years; J. W. Lieb, Jr., three years; Fred J. Miller, four years.

The President announced the reappointment of James M. Dodge on the Committee on Public Relations to serve for a term of five years.

Voted: To approve the recommendation of the House Committee that the introduction card be issued annually and serve as a receipt for dues, the details to be left to the Committee for execution.

Voted: To approve the appointment of sub-committees of the Research Committee and that the Chairman be empowered to make such appointment from men prominent in the profession irrespective of their membership in the Society.

Voted: That F. R. Hutton be appointed a member of the Committee on Power House Piping, to fill the vacancy caused by the death of Wm. H. Bryan.

Voted: To accept the report of the Special Committee, Chas. Wallace Hunt, Chairman, Robert M. Dixon, and W. H. Marshall, on plan for the liquidation of the land debt outstanding as the share of this Society, leaving details of its execution to the committee.

Voted: That the report of the Treasurer of the United Engineering Society be placed on file and that the condensed report as prepared by the President and Treasurer of the Board of Trustees for the purpose of uniform publication by the Founder Societies be published in The Journal.

Voted: That F. R. Hutton and Calvin W. Rice be appointed Honorary Vice-Presidents to represent the Society at the conference proposed by the National Electric Light Association to consider the subject of resuscitation from electric shock.

Voted: To approve the action of the Secretary in responding to the invitation of the Louisiana Engineering Society to hold a meeting of this Society in New Orleans, and to further advise that the Council hopes at some future date to take New Orleans under consideration for some semi-annual meeting.

Voted: To place on file the letter of Rear-Admiral Melville in answer to the congratulatory telegram sent by the Council on his seventieth birthday, and that same be published in the next issue of The Journal.

On motion the meeting adjourned.

UNITED ENGINEERING SOCIETY

REPORT OF TREASURER

To the Board of Trustees
United Engineering Society

I beg to submit herewith report of your treasurer as of December 31, 1910.

FINANCES

From the Balance Sheet submitted herewith, it appears that our physical property, over and above the value of the building and our equity in the land, consists of building equipment amounting in value to $16,767.72, furniture and fixtures $4376.92 and library books $205.16.

During the year 1910 there was added to the furniture and fixtures account an amount representing an expenditure of $1455.72 including furniture in the Board Room and Ladies' Reception Room, directory and bulletin boards, partition and counter in Room 607, and miscellaneous items; and books for the library amounting to $205.16, the cost of the library books being charged equally to the three Founder Societies in accordance with agreement.

The principal of the mortgage on the land held by Andrew Carnegie, Esq., amounting originally to $540,000, has been reduced by payments from the Land and Building Funds of the Founder Societies to $220,000, the American Institute of Mining Engineers having made a further payment of $3000 during the year, correspondingly reducing the burden on the Founder Societies for payment of interest.

The gross operating expenses for the year 1910 were $35,961.97. Deducting the expenditures for furniture and fixtures to the amount of $1455.72, the net cost is $34,506.25, which is slightly in excess of that of 1909, due to the fact that the building is now practically full to its capacity, necessitating the use of more electric light, power, heat, etc., and a small increase in the service payrolls.

In accordance with a resolution to the Board at the meeting held on January 27, 1910, an appropriation of approximately $5000 was made out of the surplus remaining from the year 1909, and this amount ($5062.50) was invested in New York City 4¼ per cent Bonds as an addition to the Contingency and Renewal Fund as provided for in the Founders' Agreement, bringing the Reserve Fund up to $15,331.25. It is recommended that a similar appropriation be made out of the available balance from this year's operations leaving a surplus to be carried forward of $5060.88.

The assessments paid for the year 1910 by the Founder Societies each occupying one entire floor were $4500 each, representing a total expenditure by each, including interest on its full principal of mortgage on land of $11,700 reduced in each case to the extent the society may have paid of part of its mortgage share. As the associate societies are assessed approximately $10,000 for equivalent facilities, it will be seen that the Founder Societies are still carrying more than their proportion of the carrying charges for equivalent office-space occupancy in the building.

OCCUPANCY OF BUILDING

Attention is called to the fact that on January 1, 1911, the unoccu-

pied floor space in the building was equivalent in rental value to 18 per cent of the total space available for assessment, and not including room No. 705 which is used by the Trustees as a Board Room. Even this room is occasionally used by other societies or organizations.

Attention is particularly directed to the small number of times the auditorium has been occupied during the past year, 36 times in 1910 as compared with 30 times in 1909, and the relatively small demand for the two assembly rooms on the fifth floor, No. 1 having been occupied 25 times and No. 2, 53 times in 1910; as compared with 26 and 48 times respectively in 1909. The limited use made of the auditorium and of the two assembly rooms, the income therefrom barely covering their quota of the fixed charges, continues to be a problem in the economical administration of the building.

During the year 1910 there have been the following changes in the assignment of space in the building:

a Owing to the greater demand for office occupancy than for lecture rooms, the large room on the sixth floor, known as Lecture Room No. 6, has been withdrawn from the list of lecture rooms and is now occupied as an office and museum.

b The room on the twelfth floor, originally held in reserve for possible future extension of the Library or for a museum, has been utilized since the building was first occupied as a general storeroom for the three Founder Societies. In the late summer, the books and stock stored in this room were moved to other but less convenient places in the building and the room divided by partition into two sections, giving with the small adjacent lecture room on the twelfth floor, a suite of three rooms which is now used in the evenings by Columbia University Extension Courses in Architecture.

During the past year the facilities of the building were enjoyed by 60 societies, founders and associates, with a total of 251 meetings and an attendance of 30,722, as compared with 52 societies with a total of 211 meetings and an attendance of 25,338 in 1909.

LIBRARY

The attendance at the library is given in the subjoined table:

	1910	1909	1908
Day	6535	5901	5151
Night	2795	2402	2080
Total	9330	8303	7231

showing an increase in 1910 as compared with 1909 of 634 in day attendance and 393 in night attendance, a total of 1027. The library is becoming more widely known, and the books and periodicals are more and more frequently consulted by a constantly increasing number of both members and non-members.

Respectfully submitted,

(*Signed*) Jos. Struthers,
Treasurer

UNITED ENGINEERING SOCIETY

Balance Sheet, January 1, 1911

ASSETS

Real Estate, Land		$ 540,000.00
Real Estate, Building		1,050,000.00
Real Estate, Equipment		16,767.72
Furniture and Fixtures		4,376.92
New York City bonds (cost) reserve		5,231.25
New York City bonds (cost) reserve		5,062.50
Balto. & Ohio bonds (cost) reserve		5,037.50
Library books, United Engineering Soc. (in trust)		205.16
Library, adjustment accounts		164.20
Accounts receivable		3,466.00
Cash		
Working balance	$10,004.22	
For reserve fund	5,000.00	
Ways and Means Com	1,165.08	16,169.30
Petty cash		500.00
		$1,646,980.55

LIABILITIES

Balance of land mortgage, A.I.E.E.	$54,000.00	
Balance of land mortgage, A.S.M.E.	81,000.00	
Balance of land mortgage, A.I.M.E.	85,000.00	$220,000.00
A.I.E.E. equity in Building		350,000.00
A.S.M.E. equity in Building		350,000.00
A.I.M.E. equity in Building		350,000.00
A.I.E.E. equity in real estate equipment		3,346.61
A.S.M.E. equity in real estate equipment		3,346.62
A.I.M.E. equity in real estate equipment		3,346.62
A.I.E.E. payments to date in liquidation of mortgage on land.		126,000.00
A.S.M.E. payments to date in liquidation of mortgage on land.		99,000.00
A.I.M.E. payments to date in liquidation of mortgage on land.		95,000.00
Depreciation and reserve fund		20,000.00
Ways and Means Committee		1,165.08
Library, adjustment accounts		133.45
Accounts payable		1,341.26
Balance, cash, accounts receivable, furniture, etc		24,300.91
		$1,646,980.55

STATEMENT OF RECEIPTS AND DISBURSEMENTS, YEAR ENDING DECEMBER 31, 1910

CASH RECEIPTS

Balance on hand January 1, 1910	$10,099.88
Account of reduction of mortgage on land	3,000.00
Account of interest on mortgage	8,920.00
Assessment of Founder Societies	13,500.00
Assessment of Associate Societies, offices, meetings, etc	35,661.79
Library account	5,357.85
Interest on bonds and deposits	679.65
	$77,219.17

DISBURSEMENTS

Account reduction of mortgage on land	$3,000.00
Account of interest on mortgage	8,920.00
Operating expense, Cash expenditures	33,170.99
Furniture and Fixtures	1,449.72
Library account	5,271.60
Bonds purchased (reserve)	5,062.50
Accrued interest on bonds purchased	21.84
Accounts payable (from 1909)	1,150.00
A.I.M.E. office space released	2,809.33
Insurance	362.97
Library adjustment	819.89
Library books, U.E.S.	176.11
Balance on hand, January 1, 1911	15,004.22
	$77,219.17

OPERATING INCOME AND EXPENSES, YEAR ENDING DECEMBER 31, 1910

INCOME

Assessment Founder Societies	$13,500.00	
Less refund for office space released	2,809.33	$ 10,690.67
Assessment Associate Societies		23,824.30
Assessment miscellaneous (offices and meetings)		6,814.50
Telephone returns		3,284.00
Miscellaneous charges to societies		851.17
U.E.S. library book returns		205.16
U.E.S. library returns		58.21
Interest		657.81
		$46,385.82

EXPENSES

Operating expenses, gross	$34,506.25
Furniture and Fixtures, gross	1,455.72
Reserve fund	5,000.00
Insurance	362.97
Balance to surplus	5,060.88
	$46,385.82

NECROLOGY

CHARLES HILL MORGAN

Charles Hill Morgan was born January 8, 1831, in Rochester, N.Y. His parents, Hiram and Clarissa L. (Rich) Morgan, were of old New England stock, the line of his father going back to Miles Morgan, one of the founders of Springfield, Mass., who came to this country in 1636, from Bristol, England.

Mr. Morgan's father having been a mechanic of limited means, the son Charles was obliged to work in a factory at the age of twelve, and his early education was that afforded by the Massachusetts district school of seventy years ago, and short terms in the Lancaster Academy. When fifteen he entered the machine shop of his uncle, J. B. Parker of Clinton, Mass., as an apprentice.

At seventeen he determined to learn mechanical drawing and through his efforts a class for the study of this subject was formed, taught by John C. Hoadley, late member of The American Society Mechanical Engineers, then civil engineer of the Clinton Mills. Those few lessons in drawing, taken at night, after twelve hours of work in the shop, were the most important factor in establishing Mr. Morgan's mechanical career, and perhaps of several others in that class.

In 1852, when twenty-one, Mr. Morgan was put in charge of the Clinton Mills dye-house. He devoted himself to the study of chemistry with great zeal, and filled his new position with entire success, gaining valuable experience in the management of subordinates.

For a time Mr. Morgan was draftsman for the Lawrence Machine Company. Later, from 1855 to 1860, he was mechanical draftsman for the distinguished inventor and manufacturer, Erastus B. Bigelow. In association with him and Charles H. Waters, the agent of the Clinton Wire-Cloth Mills, Mr. Morgan gained an invaluable experience and may be said to have been trained in a hive of invention. Mr. Morgan introduced a system of designing and constructing cam curves for looms. This system proved of great value and was later the subject of a valuable paper read before the Worcester Polytechnic Institute, and subsequently published by Mr. Morgan in pamphlet form.

Forming a partnership in 1860 with his brother Francis H. Morgan, he was for several years engaged in the manufacture of paper bags in Philadelphia, and during a part of this time a paper mill was operated by the firm near Coatesville, Pa. Previous to this time the imperfections in machinery had made paper bag making in the United States anything but a success. Mr. Morgan perfected the equipment so that the business was placed on a commercial footing.

In 1864 Hon. Ichabod Washburn was in need of a superintendent for his works, for the manufacture of wire, at Worcester, Mass. His friends at Clinton, engaged in the manufacture of machinery and wire-cloth, warmly recommended Mr. Morgan. Mr. Washburn accordingly engaged Mr. Morgan as superintendent of manufacturing for the firm of I. Washburn and Moen of Worcester, Mass. Four years later, when a joint-stock company was organized and incorporated under the name of Washburn and Moen Manufacturing Company, Mr. Morgan became general superintendent. He made many trips to Europe for the purpose of visiting the mills of England, Belgium, Germany, France and Sweden. Through these visits, through the publications devoted to wire manufacturing, and through patents issued both in Europe and America, he kept himself informed of all changes made or improvements adopted. The fruit of this devotion was seen in the increased excellence, variety and amount of the company's manufactures. He was for eleven years one of the directors of the company.

Mr. Morgan has been most prominently identified with the development of the continuous rolling mill, and today in steel centers the world over the continuous mill is known as the Morgan mill.

The first continuous mill was designed and originally constructed by Mr. George Bedson, in Manchester, England. One of these mills was purchased by Washburn and Moen Manufacturing Company, and erected in Worcester in 1869, and constituted a great advance over the rolling previously practiced. It soon became evident that the means of handling the product of the mill were inadequate and the first important step in development was the power reel designed by Mr. Morgan to replace the old-time hand-operated reel.

Mr. Morgan's second, and very important contribution to this system, that, indeed, which marked the great difference between the Bedson mill and the Morgan mill, was the practical development of a continuous train of horizontal rolls, the Bedson mill having had alternate sets of horizontal vertical rolls. This was accomplished by pro-

viding intermediate "twist guides," which gave to the metal being rolled the necessary quarter turn between the successive sets of rolls, and proved to be so successful that the Morgan mill is the only type of continuous mill now in use. Nine years after the contruction of the Bedson mill, another mill, from new designs furnished by Mr. Morgan, was built on the Belgian and continuous plans. This mill, the result of Mr. Morgan's studies, was known as the combination mill.

The third improvement was the invention, by Mr. Morgan, of automatic reels, both of the pouring and laying types, such as are now in common use in every rod mill in the world. These reels were completed and a successful test made March 10, 1886.

In 1887, after twenty-three very active years as General Superintendent of Washburn and Moen Manufacturing Company, declining health led Mr. Morgan to resign his position, and take up what then seemed likely to prove less arduous cares.

Some years, before in 1881, he had founded the Morgan Spring Company, for the manufacture of springs, and was thus the pioneer in this line of business which, at the present, is engaged in by many firms.

Manufacturers of steel products, at this time sought his advice in engineering problems, and his reputation as an engineer was in this way widely extended. This work led directly to the formation, in 1891, of Morgan Construction Company, of Worcester, manufacturers of rolling mill and wire drawing machinery.

Mr. Morgan was active in religious, corporate, charitable and educational lines throughout his life. He was closely identified with the growth and success of the Worcester Polytechnic Institute, having been a member of its Board of Trustees since the Institution was founded about forty-five years ago. In this capacity he has rendered a service of signal importance, greater even probably in its far reaching effect than his achievements in the profession of engineering. When in March 1866, the Hon. Ichabod Washburn made his gift to establish the machine-shop and working mechanical department of the Worcester Polytechnic Institute, Mr. Morgan was elected by the trustees as one of their associates, with the expectation that he would give the shop the benefit of his great mechanical genius and large experience. The expectation was not disappointed. Mr. Morgan's sagacity, his constant oversight, his inventive genius and his great business capacity were constantly at the service of the school, and the machine shop has been entirely successful, recognized everywhere as a most important and valuable part of the Institute.

In 1893, Mr. Morgan served on the Board of Judges of the World's Exposition in Chicago.

In 1900 the Navy Department being embarrassed by conflicting commercial and political claims in its award for special gun lathes, Secretary Folger nominated Mr. Morgan one of the committee of three distinguished engineers to pass upon the merits of so vital a question.

Although many years a member of The American Society of Mechanical Engineers, he was very much surprised, when in Europe in 1899, to receive a cablegram announcing his nomination to the wholly unsought office of President. In the following December he was unanimously elected to that office and served for one year. This year, 1900, was a notable one in the life of the Society, for a joint meeting was held in England with The Institution of Mechanical Engineers. On this trip three Sovereigns, Victoria of England, Oscar of Sweden and Leopold II of Belgium, summoned Mr. Morgan to an audience. In France the unusual distinction of election to honorary membership in La Société des Ingenieurs Civils de France was conferred upon him.

Mr. Morgan was always an admirer of Henry Cort, the inventor of the art of puddling iron with coal and of rolling metals in grooved rolls, and in his Presidential address before the Society, Some Landmarks in the History of the Rolling Mill, he paid a tribute to the Englishman's genius. In 1905 he had two bronze tablets erected in memory of Cort, one of which he presented to the church at Lancaster, Cort's birthplace, and the other to the church at Hampstead, where he was buried. The tablets which are exactly alike contain a finely executed bust of Cort with an appropriate inscription.

At the time of his death Mr. Morgan was President of the Morgan Spring Company and the Morgan Construction Company. He was a member of the American Institute of Mining Engineers, the British Iron and Steel Institute, the Institution of Mechanical Engineers of Great Britain, the Engineers' Club of New York, and an honorary member of the Society of Civil Engineers of France. He was also one of the founders of Plymouth Church and its first Sunday School Superintendent and for many years served on its board of deacons.

Chas. M. Allen, George I. Alden, F. H. Daniels, J. P. Higgins, Geo. I. Rockwood and C. J. H. Woodbury were appointed Honorary Vice-Presidents to represent the Society at the funeral of Mr. Morgan.

JOHN WRIGHT SEAVER

John Wright Seaver was born in Madison, Wis., January 8, 1855, and died in Cleveland, O., January 14, 1911. He was educated in the public schools of Buffalo, N. Y., and at thirteen years of age entered the machine shop of the Shepard Iron Works of that city. His technical education was obtained at a night school to which he was obliged to walk three miles from his home, after working hard all day.

In 1873 he entered the machine shop of the Howard Iron Works, and at the age of twenty he was employed by the Buffalo Car Company as assistant superintendent in charge of about one thousand men. Leaving there, he formed the firm of Seaver and Kellogg Company, where he designed and built the first steel cars in this country. These were not commercially successful as they were too far in advance of their time. After spending a year and a half in this business, he became assistant engineer of the Kellogg Bridge Works, where he made structural iron his specialty. He began at this time to attract outside attention as an engineer. In 1880 Mr. Seaver moved to Pittsburg to become chief engineer for the Iron City Bridge Works, and while in their employ designed and built a number of notable bridges and other steel structures. In 1884 he became chief engineer for the Riter-Conley Manufacturing Company and in this capacity his reputation became world wide. He designed and built furnaces, steel works, oil refineries, gasometers, buildings, bridges and other steel constructions. He was instrumental in making this concern one of the greatest of its kind in the world. In 1886 he united with S. T. and C. H. Wellman, to form the Wellman-Seaver Engineering Company, later known as the Wellman-Seaver-Morgan Company. While with this company he was vice-president and chairman of the board, and was a director at the time of his death. In 1906 Mr. Seaver associated himself with J. E. Moore, consulting and contracting engineers, and opened offices in Cleveland, O. He continued in this work until his death.

Mr. Seaver's engineering experience was most varied, including the civil, mechanical, marine and mining branches of the profession. While in Buffalo he designed and built many large marine engines, among the most prominent of which was that for the steamer Great Western a remarkable vessel at that time. He designed and built the first gantry crane used in this country and also the first steel cars. He was authority on structural steel construction of all kinds,

as well as material handling, steel and iron manufacturing and coke oven machinery, and compiled the first standard steel railroad bridge specification, which was adopted by some of the large railroad companies.

Mr. Seaver was a member of the American Society of Civil Engineers, the Cleveland Engineering Society, and of many business and social organizations.

LOUIS R. ALBERGER

Louis R. Alberger was born April 10, 1864, at Buffalo, N. Y., and was educated at the public schools of that city. He studied enginneering chemistry at the Scheffield Scientific School, Yale University, and later joined his father in the firm of Alberger and Salt, builders of salt-making apparatus in which the vacuum system was incorporated. This brought Louis R. Alberger into close contact with the subject which he made his life study, and after superintending for thirteen years the condensing department of Henry R. Worthington, he incorporated the Alberger Condenser Company, in 1901, and later the Alberger Pump Company, and acquired the controlling interest in the Newburgh Ice Machine and Engine Company, Newburgh, N. Y. At the time of his death he was president of the Alberger Condenser Company.

Mr. Alberger was a member of the American Institute of Mining Engineers, the National Electric Light Association, the American Association for the Advancement of Science, Verein deutscher Ingenieure, and of a number of social and athletic organizations. He died in New York, January 31, 1911.

STUART E. FREEMAN

Stuart E. Freeman was born January 13, 1866, at Baltimore, Md. He received his early education at the public schools and later attended the Franklin Institute in Philadelphia. From 1883 to 1887 he served an apprenticeship in the Illinois Central Railroad shops, Centralia, Ill., at the end of which period, he was employed by the Dickson Manufacturing Company, Scranton, Pa. He later accepted the position of foreman with the A. Falkenau Machine Company, Philadelphia. From October 1892 until May 1893 he was general foreman for the Philadelphia Hardware and Malleable Iron Works and until January 1895 for the Morgan Engineering Company, Al-

liance, O. Mr. Freeman was subsequently employed by the Todd-Stanley Mill Manufacturing Company, St. Louis, Mo., the International Drill Company, Barberton, O., the Stirling Tubular Boiler Company, the Fuller Manufacturing Company, New Haven, Conn., and at the time of his death he was general superintendent of the Smith-Furbush Machine Company, Philadelphia.

Mr. Freeman was a member of the Franklin Institute and of the Engineers' Club of St. Louis. He died in Norristown, Pa., February 2, 1911.

JARVIS B. EDSON

Jarvis B. Edson died at his home in New York City, January 26, 1911. He was born in Janesville, Wis., April 30, 1845, and obtained his technical education at Cooper Union and at New York University, New York City. He saw active service during the Civil War, and being discharged from the army, July 1863, he connected himself with the South Brooklyn Steam Engine and Boiler Works, where he participated in the construction of several engines for United States war vessels notably the Mendota, Metacomet, Nyack and Nipsic. He later conducted a series of steam engine expansion experiments under the direct supervision of B. F. Isherwood, U. S. N., Hon.Mem. Am. Soc. M. E., chief of the Bureau of Steam Engineering.

On November 1, 1864, he was appointed Acting Third Assistant Engineer in the United States Navy and at the close of the war received his honorable discharge. Returning to private life, he invented and perfected the Edson time and pressure recording steam engine. He also engaged in the manufacture of various instruments required by engineers and for the precision of which he was obliged to construct a mercurial column some 250 ft. high for high pressure alongside the Brooklyn towers of the East River Bridge. This instrument received due corrections for temperature and density, and differed from the guesswork method previously practiced for obtaining standards from which to lay off the dials of hydraulic and other high pressure instruments. In 1873 Mr. Edson took part in the organization of the Domestic Telegraph Company and three years later devoted his attention to the manufacture and improvement of celluloid and zylonite. During this peroid he obtained many valuable patents on inventions, one of which was for a method of making artificial ivory in proxilene compounds. He also devised a novel method of sinking deep wells into clay, quicksand, gravel, etc.

Mr. Edson's naval experience coupled with his characteristic pa-

triotism prompted his notable activity in organizing the New York Commandery, Naval Order of the United States, of which he was a charter member and the Navy League of the United States. He was a member of the American Society of Naval Architects and Marine Engineers, American Society of Naval Engineers, Franklin Institute, National Geographical Society, Engineers' Club, Army and Navy Club and several others.

WILLIAM HARRISON CORBETT

William Harrison Corbett, President of the Williamette Iron and Steel Works, Portland, Oregon, died at his home in that city on February 20, 1911, after a brief illness. Mr. Corbett was born in Brooklyn, N. Y., on October 31, 1868, and was graduated from Stevens Institute in the Class of 1895. Before entering Stevens he had served his apprenticeship in the Rowland Machine Works, New Haven, Conn., and immediately upon graduation entered the field of mechanical engineering in New York City. In 1900 he removed to Portland, Oregon, to assume charge of the Williamette Iron and Steel Works, becoming President after the works were rebuilt some years ago.

Mr. Corbett followed the family trend as an iron manufacturer and ship builder, being the eldest son of Charles H. Corbett, Vice-President of the Continental Iron Works, and a grandson of the late Jeronemeus S. Underhill, one of the pioneer builders of iron vessels before the Civil War.

THE ECONOMIC IMPORTANCE OF THE FARM TRACTOR

By L. W. Ellis

ABSTRACT OF PAPER

The human race uses power for tilling the soil, manufacturing and transportation. Mechanical power in a large measure effected the removal of manufacturing from the home to the factory and the organization of land and water transportation on an unprecedented scale. Agriculture has been slow to accept mechanical power, because it has made better use of animal power. Capital necessary for the development of motive power for the farm has been occupied elsewhere and apparently inexhaustible soil fertility has enabled the old, inefficient methods to supply the demand for foodstuffs. Agricultural machinery has been developed with primary reference to the character of the power used. The engineer has had little to do with its design.

We now face a probable shortage of foodstuffs. Deeper plowing and better tillage must lay the foundation for greater yields. Only mechanical motors can supply the power for deep plowing without increasing the proportion of our crops needed to support the source of power. The tractor fits easily into the present farm scheme and solves many problems. It raises others and is almost certain to lead to the organization of the farm on a larger and more economical basis. Capital and brains are now concerned with the problem of cheaper production. There is a field for the mechanical or agricultural engineer in the rehabilitation of farm machinery, the development of farm motors, and on the larger farm itself, in the installation and superintendence of machinery and power.

O.K.

THE ECONOMIC IMPORTANCE OF THE FARM TRACTOR

By L. W. Ellis,[1] La Porte, Ind.

Non-Member

Now, as in the beginning, the human race uses power for three great fundamental occupations: tilling the soil to produce materials; changing the shape of materials to adapt them for use; and carrying either the raw or manufactured product from place to place. In other words, power is required for agriculture, manufacturing and transportation.

2 Of these, agriculture, man's fundamental occupation, is the last to feel the need of mechanical power. In adapting animal power to human needs, the tiller of the soil has in all ages surpassed his contemporaries in the arts and commerce. But with animal power, even on the large farm, there has been little possible variation in methods and equipment from those of the small one. The possible manipulation of animal power by a single laborer quickly reaches its limit. Thereafter the increase in size of the farm is attended by increasing complexity of organization, involving more labor, deputized management and, usually, a decrease in efficiency as compared with the smaller holding.

3 With our present rural organization we are pressing on the limits of agricultural production. We are no longer exporting vast quantities of breadstuffs. We are earnestly considering the question of what we must do to be fed, and the problem of farm power overshadows all other factors involved in obtaining the answer. To provide permanently a sufficient supply of food, teachings of agricultural scientists must be universally heeded. Better seed, deeper plowing, more thorough tillage, must lay the foundation for greater

[1] Traction Plowing Specialist, M. Rumely Co.

The American Society of Mechanical Engineers, 29 West 39th Street, New York. All papers are subject to revision.

yields from each acre. Waste places must be reclaimed, our whole productive area developed and occupied. But our present needs are enormous, increasing more swiftly than these ideals can be realized. Greater areas must be brought immediately into productiveness and they must maintain maximum yields indefinitely, if production is to keep pace with demand.

4 The lack of power for plowing and harvesting is the tremendous obstacle to the sudden expansion into virgin fields of our productive area. The shallow plowing now generally practiced consumes 60 per cent of the total power expended in raising and harvesting the wheat crop, even on old land. Deeper plowing to secure maximum yields sharpens the necessity for power in the brief plowing season. The slow process of animal reproduction cannot respond quickly enough, and the price of horses has increased 143 per cent in ten years in spite of a 50 per cent increase in the supply. Today in Canada, where great added power is imperative, horses can be purchased only in limited numbers. Even the United States Department of Agriculture cannot find an adequate supply of brood mares for the future needs of the New South. Increased production cannot safely depend on animal power.

5 Nor is production the only consideration. Fifteen million work animals, and the 10,000,000 more to keep up the supply, scarcely develop sufficient power for present farm purposes. Their feed alone costs $1,250,000,000 per year, equalling the total income of 2,000,000 average families. Thus the crops from one acre in five are withheld from supplying human needs by the use of animals for farm power.

6 Cheap mechanical power on the farm can be made to combine the intensive culture of the small farm, well-tilled, with the economical production of the large farm, well-managed. It is already doing so on the immense sugar-beet ranches of California, where 10,000 acres of beets may be handled by a single management with specially designed engines and machinery. Dr. S. A. Knapp, of the Department of Agriculture, who is revolutionizing farm methods in the South, says that profitable farming has become a power and implement problem. Out of a gain of 200 per cent over the average crop he found better plowing and pulverizing of the seed-bed added 100 per cent; better cultivation, 50 per cent; and better seed, 50 per cent. Mechanical power need not impair fertility, as leguminous crops, gathering nitrogen from the air, can be plowed under more easily, and other animals can be kept which will produce human

food instead of power, and return to the soil manure of even greater fertilizing value.

7 For a quarter of a century mechanical power has taken the place of animal labor for operating stationary machinery on the farm. The small stationary gasolene engine of the last decade has relieved both man and horse of a host of minor duties. The automobile on many a farm has assumed the place of the light roadster and restricted the draft horse to the heavy work of the field. The farm field is the last and greatest stronghold of the horse, and the most difficult place for the substitution of mechanical power. But now, for large units at least the farm tractor has become a fixture.

THE FARM TRACTOR

8 The farm tractor is the solution of the immediate problem. Of all the sources of power it fits most easily into the present scheme of things. Excepting the thresher and the engine gang plows we have no field implements or machinery especially adapted to the use of mechanical power. The prime mover which shall take the place of the horse must therefore be capable of drawing implements designed for utilizing the horse's power, at least until other means of applying power to the soil shall have been developed.

9 The farm tractor does not age nor deteriorate when idle, and requires neither fuel nor attendance when not at work. The time spent annually in caring for a horse will keep the tractor in perfect working condition. It will endure heavy work 24 hours a day instead of 6, and outlive the average work animal in hours of service. It occupies less floor space than two wagons, and with a year's fuel supply may be sheltered in a building a tenth the size and cost required to house and maintain horses of equal power.

10 Efficient farm labor grows increasingly scarce. The tractor concentrates in one man's hands the power of 25 horses and the endurance of 100, and adds two-fold to the acres he can cultivate. By condensing crop operations within the period when the most favorable conditions prevail, it adds to the quantity and quality of the product. Every horse displaced by this new power saves five to eight more of these acres for human maintenance, for the mechanical motor consumes nothing which could be converted into food for mankind.

FARM MACHINES AND THE ENGINEER

11 The history of the average farm machine covers a period of cut-

ting and trying, of successive increase and decrease of the size of parts, of change of this and that, until every part is as strong and as light as the next. The great difference between the average farm machine and the celebrated "one-hoss shay" is that the latter was built to last for a century, while the former is built, first, to conserve power; second, to be sold at a low cost; and, finally, to last as long as it will. To meet the requirements of the situation, inventive genius, patience and perseverance have been needed, rather than high technical ability. Perhaps the latter was more than once tried and found wanting. Suffice it to say that McCormick, Deere and other great creative spirits were of the so-called practical type.

12 Machines of small capacity have had to be created for a hundred tasks formerly performed by hand. So frequent were improvements that until recently the durable machine might become obsolete before yielding a profitable return. The average field machine is in use but a few days each year, and a life of 500 working hours is probably above the average. High cost, then, is not justified and the American farmer likes to buy on price.

13 A mechanical engineer connected with the manufacture of farm engines once expressed his contempt for the self-binding harvester as a machine, and his admiration for the men who developed it. Said he, "Given the same problem, with his data on stresses and strains, his factor of safety, and his highly trained caution, the mechanical engineer would have produced a binder which would work and wear forever, but which would be so heavy, and cost so much, that a practical farmer would never hitch a team to it."

14 The character of the machinery man utilizes is determined largely by the type of power available for operating it. On the farm where the power needs are varied in the extreme, where during seed time and harvest an enormous peak-load must be carried economically, the prevailing power has been one which required food, water and shelter, attendance and exercise 365 days in the year, a power which must be kept in constant readiness nearly 9000 hours for less than 1000 of service. The available power installation on the average farm has been therefore, a compromise between the amount required properly to do the work in two seasons of the year and the excessive maintenance charge imposed during the off-seasons. To reduce the peak-load has been the great problem, hence efficiency and durability of farm machines have only too often been sacrificed to the absolute necessity of light draft.

15 The tractor at the present time is much better in design and

execution than the average piece of farm machinery, and the handiwork of the mechanical engineer is to be noted in its make-up. However, even this field has been occupied largely by manufacturers trained in the usual school of experience. Many features of the present type of tractors are those of the investor rather than of the engineer with his facilities for editing the ideas of others. Ideas have come so thick and fast, the demand for tractors has been so great, and willing investors so numerous, that often only a single new idea has been necessary to call forth a working machine. Many are built around a single meritorious feature, the remainder of the machine being sadly out of balance. There are problems enough here not calling for inventive ability. There is the possibility of further refinement and greater efficiency in the steam tractors, perhaps the adoption of a system of superheating.

16 Centralization of farms and the shaping of farm processes to less extreme power requirements will take place slowly. There is therefore, the problem of the small tractor, both for universal use on the small farm, and for light work on the large one where a greater power unit is also employed.

17 Just now there is the type of tractor, which must be fixed; the best number of cylinders, speed of engine, tractive speed, size of drivers and distribution of weight; the kind and quality of materials and the best methods of construction. There is particularly the adoption of a practicable standard for rating tractors, the use of which would be of the greatest value to the non-technical purchaser.

18 The present offerings afford an ample basis on which to work out the final solution. Besides the wide variety of direct tractors, we have the cable-drawn implement with power stationary; the self-propelling machine, securing traction by grip on a cable instead of the soil; the machine with traction and working parts separate, the former operated by either animal or mechanical power, and the latter of rotary type, driven by mechanical power exclusively. The ultimate need is for a durable, self-contained plant, so light as neither to waste power in moving it, nor to compress the ground in passing over it, capable of performing every operation from driving a stationary machine to plowing, pulverizing, seeding, cultivating, harvesting and hauling the crop. It must be low in cost, both initial and operative, economical of labor and repairs, and capable of utilizing economically whatever fuel may be most abundant and easily procurable.

19 The success of mechanical power on the farm depends largely on an adequate supply of cheap fuel. The recent development of a

successful oil-burning tractor using the heavier, cheaper and more abundant grades of kerosene is a distinct achievement, a feat of tremendous importance in the advancement of this great movement in agriculture. The ultimate type of farm power will undoubtedly depend upon the acreage required to supply it with fuel, owing to the rapidly growing needs of the human race. The horse is capable of little further improvement in economy; the actual refinement of the tractor has scarcely begun. Here are problems for the engineer, the chemist and the agriculturist. The three, working hand-in-hand, can set forever at rest the question of our interdependent food and power supplies.

WHERE THE TRACTOR IS MOST EFFICIENT

20 The commercial efficiency of the present tractors is based largely on local conditions, such as the price of fuel, the accessibility and quality of water, cost of labor, topography, type of farming and volume of work. It is greatest in sections where they may be used for general farm work. This, for the larger and more common types, implies large tracts of land, and of course the lowest possible grades. The distribution of work on small grain farms favors the use of the tractor rather than the horse.

21 The cheapness with which the tractor breaks up virgin land and the simplicity of maintenance during idleness make for its use in the newer districts. The rapidity with which these sections are being settled is due quite as much to the use of mechanical power for plowing as to the extension of railway facilities.

22 In the colder climates, where all crop operations must be rushed and in climates where heavy work must be done under conditions of extreme heat the tractor naturally excels the animal. On the other hand, where work may be extended over long periods, and where corn, cotton and other inter-tilled crops require the use of a small power unit for cultivation, the lack of a small, flexible tractor favors the use of the animal. Even in these sections, however, the experiment station authorities unanimously maintain that depth of plowing and larger yields are commonly sacrificed because of a lack of power.

23 Three years ago, in a bulletin on traction plowing prepared for the Department of Agriculture, I stated that, taken as a whole, traction plowing could hardly be said to be cheaper than horse plowing, especially if gang plows were drawn by the horses. This was based on the observation that many operators used their engines only

for plowing and threshing, and the assumption that the average life of an engine would be about seven years. Both conditions are constantly being modified to reduce the overhead charges. Tractors are now used for plowing, discing, seeding, harrowing, summer fallowing, back-setting, harvesting, threshing and hauling, besides such jobs as running clover hullers, huskers and shredders, saw mills and the like. The volume of work provided becomes much greater as the tractioneer learns the possibilities of his outfit, and nearly every outfit now does some custom work.

STEAM VS. INTERNAL COMBUSTION TYPES

24 Moreover, improvement in durability and efficiency of both steam and internal-combustion tractors has been great, even in the short interval, and the compact engine-gang plows, now commonly used, are models of convenience as compared with the wide variety of types only recently employed. These quick changes have been forced upon manufacturers by the universal demand for better equipment for plowing. Schools of traction engineering, too, have aided much by increasing the efficiency of operators. Even if the earlier statement were still true, the question of cost is often a minor item, the net returns from a crop being dependent on the ability to perform necessary operations with a minimum of time. The capacity and endurance of the traction engine outweigh all other considerations in a crisis.

25 At western points distant from the refineries and close to coal fields and good water supply, steam engines may have the advantage of the internal-combustion type. In the nearer West the latter have come into use with a swiftness that is amazing when one considers that the first one to prove successful was launched only about eight years ago. Their economy in small sizes, their convenience, safety around buildings, and the fact that operators are not usually required to hold licenses, commend them strongly. Wonderful tank wagon service now brings fuel for the oil-burning engine direct to the farm at wholesale prices, an engine often yielding as great a profit to the refiner as a town of 600 inhabitants.

26 To date, no kerosene-burning tractor has achieved the thermal efficiency secured by the foremost gasolene tractors, but in all except the most remote districts the wide and growing disparity in fuel cost gives the former a marked commercial advantage.

27 The internal-combustion engine is economical of labor as compared with either steam or animal power. In plowing, for instance,

two men, with only occasional attendance by horses, are required for both engine and plows. For steam-plowing outfits I found an average of 6 men and 5.5 horses in California; 3.4 men and 3.1 horses in the southwestern states; and 4.2 men and 4.5 horses in the northwest. The engineer and plowman should be of the same caliber in either case, but the extra labor and board involved in operating the steam tractor is a serious handicap on small outfits. The capacity of the steam engines which as a rule are the larger, their fuel economy in some sections, and the fact that as a class they have been more reliable, have tended to equalize matters. The initial cost per horsepower is much less for steam than for internal-combustion tractors, but a somewhat greater outlay must be made in providing for the transportion of coal and water, and for the comfort of horses and extra men.

SOURCES OF DATA

28 The data which I have on the performance of tractors are largely from two sources, the agricultural motor competitions which have been held at Winnipeg and Brandon, Manitoba, and investigations which I conducted among every-day operators in connection with the United States Department of Agriculture. The former should be thoroughly reliable, but in some cases are open to doubt, the tests having been conducted hastily and without adequate facilities. The latter source is reliable only in that it averages the testimony of a large number of operators, few of whom had exact records. The tests conducted in the four motor competitions have been on the brake, first for economy, then for maximum power; in plowing, over firm, level prairie sod; and in hauling, over a half-mile circuit which presented almost every possible road condition from block pavement to loose gravel and mud. The various averages hereinafter presented are offered merely as a basis for rough comparison with the performance of motors used in other service.

COAL AND WATER CONSUMPTION

29 Table 1 shows the average coal and water consumption in the economy brake tests of steam tractors in Canada. It is not to be supposed that the load in every case was exactly at or even near the point of greatest economy, though this condition was usually aimed at. There was but 1 test of a compound engine on the brake, against

6 single and 11 double cylinder engines. In plowing there were 4 single and 6 double; and in hauling 1 single and 3 double.

TABLE 1 LB. OF COAL AND WATER USED PER DELIVERED H.P. PER HR.

TEST	SINGLE CYLINDER		DOUBLE CYLINDER		COMPOUND	
	Coal	Water	Coal	Water	Coal	Water
Brake.....	3.72	30.11	4.43	32.43	4.96	34.94
Plowing.....	7.46	52.8	8.87	69.0	....	.....
Hauling.....	14.18	114.6	12.84	91.1	....	.....

30 Steam tractors as a rule use from 7 lb. to 8 lb. of water per lb. of coal. Reports from 333 plowing engines of all types in the United States and Canada indicate an average of 7.67 lb. Twenty-four public brake tests show a mean of 7.78 lb.; 16 plowing tests 7.08 lb.; and 4 hauling tests 7.4 lb.; or a mean of 7.42 lb. for the 44 tests. Single cylinder engines show a range of from 5.78 lb. to 9.97 lb.; and double cylinder from 3.3 to 10.3 according to the official reports. Conditions were such however, as to arouse doubts as to the accuracy of such extreme figures. By making enough assumptions we can compare these data with those furnished by operators of 11 oil-burning steam engines in California. These men report the use of 9.4 gal. of water per gal. of oil. Assuming the oil to be of 20 deg. Baumé and to contain 20,000 B.t.u. per lb. they use 1990 B.t.u. in evaporating 1 lb. of water. The ordinary run of coal used contains not over 13,000 B.t.u. per lb., hence 1700 to 1740 B.t.u. would be furnished per 1 lb. of water.

GASOLENE CONSUMPTION

31 Table 2 gives an average of gasolene consumption in all public economy tests to date.

TABLE 2 GASOLENE CONSUMED PER DELIVERED H.P. PER HR.

TEST	1 CYLINDER		2 CYLINDERS		3 AND 4 CYLINDERS	
	No. Tests	Lb. Fuel	No. Tests	Lb. Fuel	No. Tests	Lb. Fuel
Brake.....	11	0.567	4	0.836	12	0.965
Plowing.....	6	1.273	4	2.076	9	1.778
Hauling.....	5	1.536	1	3.97	6	1.88

32 The average consumption for 27 brake tests is 0.747 lb., or a trifle over a pint per h.p-hr., the gasolene used being of 70 specific, 64 Baumé gravity. Nineteen plowing tests average 1.67 lb., and 12 hauling tests 1.91 lb., per drawbar h.p-hr. These averages are not comparable, but the matter of tractive efficiency will be discussed later.

33 The amount of water required per brake horsepower-hour by the internal-combustion motors depends largely on the cooling system. In these tests it ranged from 0 to 2.55 lb. per h.p. per hr., averaging in the neighborhood of $1\frac{1}{3}$ pints. A kerosene tractor, using water in the cylinders, consumed less than a pint of water per h.p-hr. The consumption by the evaporative type of cooler would in several instances have necessitated replenishment of the water supply after from two to three hours of heavy work.

THERMAL AND TRACTIVE EFFICIENCY

34 No analyses have been made of fuels used at the motor contests, hence the thermal efficiency of the various engines is in doubt. It probably ranges from 4 to 6 per cent for the steam tractors, and from 6 to 25 per cent for the internal-combustion type. Neither have tests been made of the boiler, mechanical or real tractive efficiency.

35 The fuel consumption in the brake tests bears direct relation to the number of cylinders. In the plowing and hauling tests the efficiency of the traction parts is brought also into play. Tests bringing out comparisons of the traction mechanism only have never been conducted, hence we are forced to use a crude comparison of fuel consumed and horsepower developed in the various tests. This topic deserves extended discussion, and Table 3 will serve to bring out only in a rough way the influence of various factors on tractive efficiency.

36 The small, single-cylinder motors had wheels much larger in proportion to total weight than the other classes, but more weight, also, per brake horsepower developed in the economy test. Comparing only the brake and drawbar horsepower they appear to have greater tractive efficiency than the larger and heavier machines. From the comparative fuel consumption however, we may assume that this was due rather to harder work of the engine, i.e., more brake horsepower was being developed during the plowing than during the economy brake tests. As previously stated, the road conditions were severe, every class developing in the hauling tests a lower per-

centage of the brake horsepower at the drawbar, and using more fuel per tractive horsepower-hour than in the plowing tests.

37 The light high-wheeled tractors with four-cylinder high-speed engines seemed to be much less affected by the adverse conditions, developing in either plowing or hauling about half as much tractive horsepower as brake horsepower, with approximately twice the fuel consumption per unit. The steam engines, with only a trifle more weight per brake horsepower than the four-cylinder gasolene tractors, and about the same height of drivers, but over 40 per cent more weight per inch in width of drivers, were able to turn this weight to good account in plowing on firm footing. Over the hauling course power dropped and fuel consumption rose in nearly the same proportion.

TABLE 3 TRACTIVE EFFICIENCY TESTS

DETERMINED BY COMPARING FUEL CONSUMED AND HORSEPOWER DEVELOPED AT WINNIPEG, MAN., JULY 1909

Type of Engine	Total Weight per 1 in. width of Driver	Weight per Economy B.h.p.	Drawbar h.p. B.h.p.		Fuel per B. h.p-hr. Fuel per drawbar h.p-hr.	
			Plowing	Hauling	Plowing	Hauling
Single-Cylinder, Gasolene, Low Wheel..	299	535	0.614	0.508	0.441	0.355
Four-Cylinder, Gasolene, High Wheel.....	407	416	0.531	0.499	0.538	0.533
Steam.....	585	456	0.566	0.293	0.499	0.344

NOTE.—This table includes four single-cylinder gasolene engines, three 4-cylinder, and four steam engines.

38 The drawbar pull of the gasolene tractors averaged about 17 per cent of the total weight in the hauling test and about 24 per cent in plowing. One horsepower was developed for 922 lb. of total weight. The drawbar pull of the steam engines was approximately 11 per cent of the total weight in hauling and 22 per cent in plowing. Averaging the two tests, the steam tractors have credit for 1 tractive h.p. for each 1033 lb. of weight.

39 This year the steam tractors delivered in plowing from 50 to 77 per cent of their economy load on the brake and from 37 to 58 per cent of their maximum. The dynamometer showed a mean resistance of 26 per cent of the total weight and 36 per cent of the weight on the drivers. The latter weight is probably only approximate.

A mean of percentages indicates that 73.5 per cent of the weight is borne by the drivers.

40 Seven internal-combustion tractors had a mean resistance of 25 per cent of the total weight and 35 per cent of the weight on the drivers, the latter carrying 70 per cent of the total. Data on a motor truck which overcame a resistance of 33 per cent of the total weight and 79 per cent of the weight on the drivers are excluded. This motor carries only 42 per cent of its weight on the drivers, and in the plowing test was loaded with human ballast to increase the percentage.

41 The rating of tractors is far from uniform, but steam ratings are more conservative than for internal-combustion engines. The brake rating of steam tractors is seldom less than three times the tractive or nominal rating. In tests this year every steam tractor not only exceeded both brake and tractive ratings, but developed a greater percentage of its maximum brake horsepower at the drawbar than was indicated by the ratio of tractive to brake rating.

42 Only two internal-combustion engines equalled their brake rating on the maximum test and only one its drawbar rating in plowing. The class averaged only 86.5 per cent of the brake rating on a maximum test, 80.9 per cent of the tractive rating on a semi-economy test in plowing and 80.9 per cent of their brake rating on an economy load. The steam engines exceeded the specified horsepower by 32 per cent, and the tractive rating 95 per cent, besides carrying 97 per cent of the rated brake horsepower on the economy load.

43 The daily capacity of a tractor depends on the width of the strip plowed or otherwise treated and the distance traveled. The former depends largely on tractive power. The character of machine drawn affects the distance traveled by governing somewhat the number of stops. Stops, however, are due more often to the necessity for taking supplies or making repairs.

44 The steam tractor formerly required a large amount of time for taking on supplies, but it is now easy to take water on the move, and, the transfer of coal, if sacked, is a small item. The internal-combustion tractor can usually travel a much greater distance without replenishing supplies than the steam tractor, though apparently little effort has been made to balance the capacity of fuel and water tanks. Were it possible entirely to empty either tank, nearly every internal-combustion tractor could travel 10 to 15 mi. under full load without stopping, while the average steam tractor requires a supply of water approximately once every 2 mi. and of coal every 5 or 6 mi.

DAILY CAPACITY OF TRACTORS

45 Sixty steam plowmen in the northwest average 1.48 mi. of furrow travel per hr., and 100 in the southwest average 1.5 mi. With internal-combustion tractors these were increased to 1.73 and 1.68 mi. per hr. respectively. These figures take account of all delays. Actually the traveling speeds are much higher. In one hauling contest, with no stops except for supplies, seven gasolene tractors netted 2.39 mi. per hr., or 92 per cent of the rated high speed, which averaged 2.59 mi. Four steam tractors netted 2.2 mi., or 86 per cent of the rated high speed. The previous year over the same course the gasolene tractors averaged 2.99 mi. per hr. One farm truck maintained 4.42 mi. per hr. with a load 50 per cent greater than its own weight. The same tractors which averaged 2.99 mi. per hr. in a nonstop haulage test averaged only 2.04 mi. of furrow travel per hr. in a plowing contest. The furrows in this case were short, necessitating many turns. Each turn takes from 45 sec. to 2 min., hence the net furrow travel was cut to 68 per cent of the hauling speed. Last year, with a longer course (120 rods) six gasolene tractors in plowing averaged in net furrow travel 74 per cent of the rated high speed and 80 per cent of their hauling speed.

46 This year, on a run of practically one mile, 97 per cent of the travel of one tractor was in useful work. The internal-combustion tractors this year averaged 1.86 mi. of furrow travel and the steam tractors 2.22 mi., in tests averaging about five hours. These are not far from the actual traveling speeds in difficult plowing, as there were few stops for supplies or turning.

COST OF OPERATION AND PRODUCTION

47 Comparisons of cost of operation are usually unsatisfactory, owing to the dominating effect of local conditions, and the personal element. Anywhere from 5 to 20 h.p-hr., may be needed to plow an acre. Ordinary loam shows a resistance of from $4\frac{1}{2}$ to $5\frac{1}{2}$ lb. per sq. in. of cross-section of the furrow slice, say 360 lb. for a furrow 6 in. by 12 in. In plowing an acre of this soil, the 12-in. plow will travel 43,560 ft. and require 7.9 h.p-hr. of work, in addition to the turns, etc. At Winnipeg it required from 12 to 19 h.p-hr. to the acre, plowed 4 in. deep. The transportation of supplies is a highly variable factor. In fact all factors are, and after trying for two years to

secure dependable averages, I was forced to generalize in a report dealing with the situation.

48 The manager of a noted Dakota farm this year puts the cost of producing an acre of wheat with horses at $8.45. A traction farmer in the same state produced a 2000-acre crop of flax last year for $6.56 per acre, allowing for all overhead charges. Roughly speaking, the tractor cuts ten cents from the cost of producing a bushel of wheat in a 20 bushel crop. Table 4 summarizes the comparative cost of production with horses and an oil-burning tractor for conditions in eastern North Dakota. Overhead charges on prime mover are included in the several costs of operations. Machinery costs for the tractor are a trifle higher because of the added investment in suitable plows.

TABLE 4 COMPARATIVE COST OF PRODUCTION

Cost of Production per Acre of Wheat	With Horses	With Tractor
Land rental	$2.00	$2.00
Plowing	1.35	0.76
Seed	1.13	1.13
Pulverizing and seeding	0.63	0.17
Twine and cutting	0.75	0.39
Shocking	0.22	0.22
Threshing	0.65	0.65
Machinery costs	0.62	0.67
Hauling	1.00	0.26
Incidentals	0.30	0.30
Total	$8.65	$6.55

49 The cost of keeping animals is increasing. The scarcity of lumber is making buildings for shelter more costly, Labor is higher in price, as is horse feed. The average farm horse gets 10 lb. of food ($6\frac{1}{2}$ lb. of hay and $3\frac{1}{2}$ lb. of grain) for every hour he works, and some pasturage beside. His thermal efficiency is around 6 per cent when worked ten hours a day and skilfully fed, but ordinarily only around 1 to 2 per cent. Much of his work is light and he probably returns not over 500 h.p-hr. per year for the $100 which it takes to keep him. Other advantages than cost have given the tractor preference over the animal to date, but as the transition continues the comparative cost will vary increasingly in favor of mechanical power.

THE OPPORTUNITY FOR THE ENGINEER ON THE FARM

50 I have indulged in not a little prophecy, yet current events seem to indicate that it is not all idle. Mechanical power has come to the

farm and displaced the animal in countless instances. The old-time bonanza farms have largely been broken up into small holdings, on which the personal interest of the home-loving owner has proved more effective than the long-range management of the wheat baron. But a new type of large farm, owned by the stock company, managed by a scientifically-trained business farmer, and operated largely by mechanical power, is multiplying in the West. Men of means, for pleasure, perhaps, but also for experience and profit, are dabbling in farm ownership. The farm has been subjected to analysis by the soil expert, the chemist, the botanist, and pathologist, the plant and animal breeder, the economist, and, finally, by the business doctor. Now, for the first time, it is being analyzed as an engineering proposition, for after all these authorities have laid down the plan, the execution of it is largely an engineering problem. Thoughtful, far-sighted men have seen that the farm of the future will be one on which the efficiency of the equipment will largely measure the success of the enterprise. Four-year courses in agricultural engineering are already graduating men with a knowledge of civil, electrical, hydraulic, and most of all, mechanical engineering. The agricultural engineer must know something of all these branches, and more. He must know the problems of the farm; in short, must be an alert, well-equipped, all-round man. But his opportunity will be well worth the necessary training. He will install machinery, erect buildings, plan the water supply, irrigate or drain as the case may be, superintend the maintenance and perhaps the operation of all equipment. His life will be in the open, with all the conveniences and opportunities for mental development that the modern farm will afford. His will be an honored profession, his career a constant stimulus to breadth of vision and intellect.

COMMERCIAL APPLICATION OF THE TURBINE TURBO-COMPRESSOR

By Richard H. Rice

ABSTRACT OF PAPER

The paper describes a compressor unit for blast furnace work consisting of a four-stage Curtis steam turbine direct-connected to a six-stage centrifugal compressor. This was built and installed at Oxford Furnace, N. J., by the General Electric Co., and is the first of this type of apparatus to be made in this country. It is governed automatically by mechanism which depends for its action upon a change in the rate of air flow, by which means the speed of the turbine is varied as required. The governor regulates the volume of air delivered per minute so as to keep the rate of discharge constant at the value determined by the furnace superintendent. It is found that on account of the steadiness of operation and more uniform conditions the output of the furnace has been increased and it is concluded that, considering all the factors, the centrifugal compressor as a blowing apparatus can be operated at a lower net cost than any other means for blowing furnaces. The paper contains data upon sizes and capacity of the apparatus with diagrams showing the characteristics of its performance.

COMMERCIAL APPLICATION OF THE TURBINE TURBO-COMPRESSOR

By Richard H. Rice, West Lynn, Mass.

Member of the Society

The General Electric Company recently put in operation at the Oxford Furnace, N. J., plant of the Empire Iron & Steel Company, a turbine-driven air compressor (Fig. 1) for blowing the blast furnace, which is the first installation of this type of apparatus to be made in this country.

2 The unit consists of a six-stage compressor operating at a normal speed of 1650 r.p.m. and driven by a direct-connected four-stage Curtis steam turbine. The design is such that this normal speed produces a blast pressure of 15 lb. per sq. in. The unit, however is designed to regulate the volume of air delivered per minute so as to keep the rate of discharge constant at any value, determined by the furnace superintendent, within its capacity. The manner in which this is accomplished will be fully described in the sequel, but it may be said here that the regulation is by means of speed variations, so that the machine is a constant-volume, variable-speed apparatus, and not a constant-speed as in other classes of blowing units.

3 The compressor has six stages arranged in series, so that the air enters at the end nearest the steam-turbine driver and passes successively from stage to stage until it reaches the other end of the compressor casing, where it enters the discharge pipe. The impeller wheels are so designed that there is no unbalanced end thrust, so that the ordinary means used in the Curtis turbine for locating the rotating elements and preserving proper clearances are sufficient for the entire apparatus.

4 The air is cooled in each stage during compression and also in passing between stages by suitable water chambers in the diaphragms, and this cooling is sufficient to maintain the compression approximately along the adiabatic line.

The American Society of Mechanical Engineers, 29 West 39th Street, New York. All papers are subject to revision.

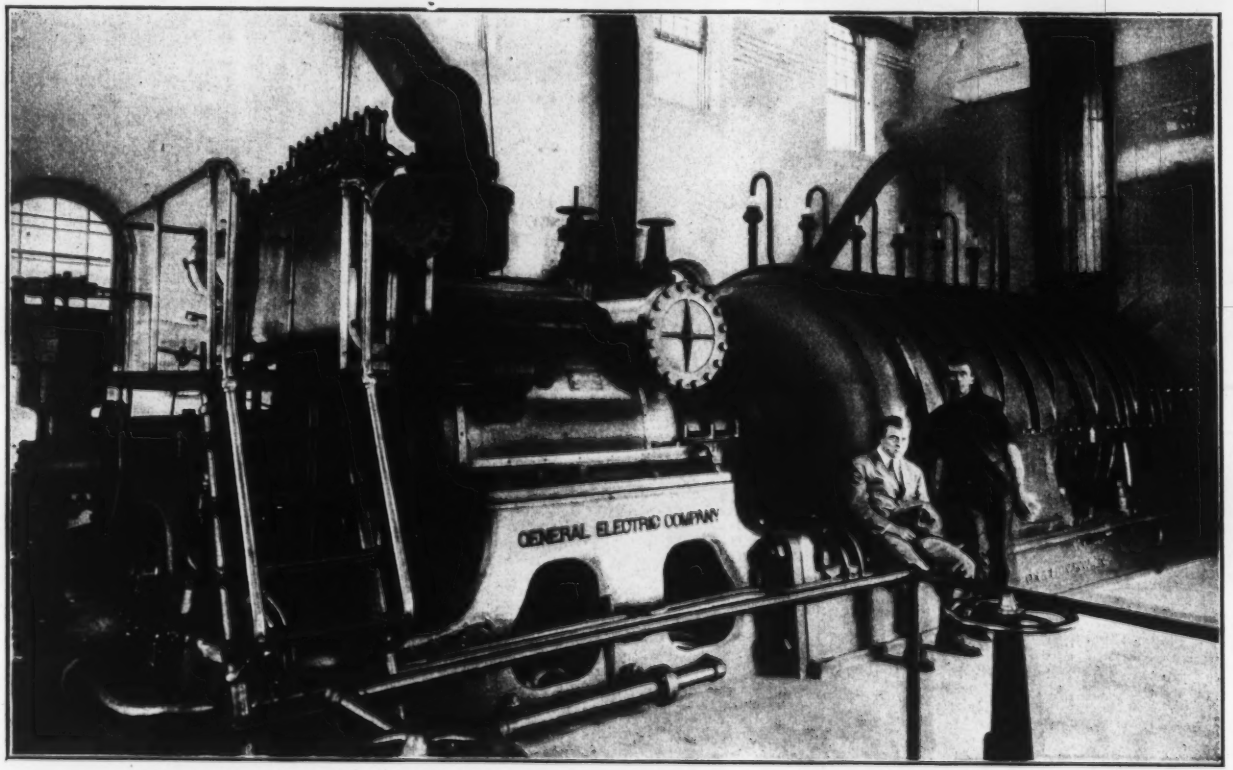


FIG. 1 AIR COMPRESSOR DIRECT-CONNECTED TO CURTIS STEAM TURBINE, 1500 R. P. M. EMPIRE IRON & STEEL CO., OXFORD FURNACE, N. J.

5 No valves or rubbing surfaces are used in the compressor construction and, as in the turbine, the rotating elements revolve freely with ample clearance so that no wear or deterioration can take place; therefore, the efficiency of compression must remain constant.

6 Fortunately, both turbine and compressor attain their best efficiency under similar conditions as regards rotating speed, making the combination a logical and efficient one. Under conditions usually met with in blast furnace operation involving pressures of blast of 10 to 20 lb. per sq. in., the efficiency remains sensibly the same. A

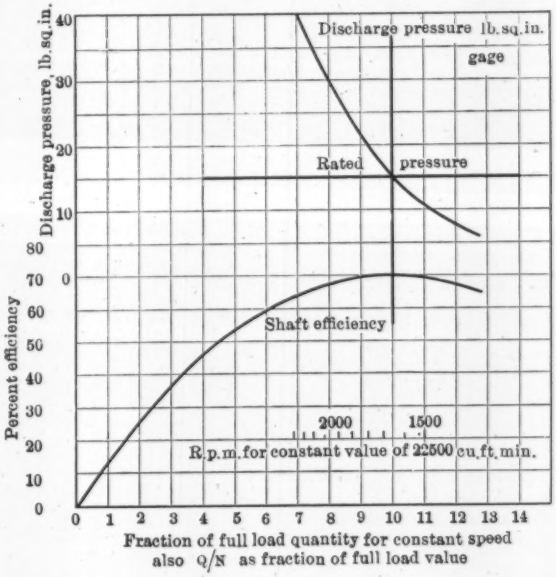


FIG. 2 EFFICIENCY AND PRESSURE CURVE WITH CONSTANT-VOLUME GOVERNOR. COMPRESSOR WITH SIX STAGES

curve of efficiency at varying volumes is shown in Fig. 2 and above this has been drawn a curve of speeds and pressures which, taken in connection with the first named curve, shows the variations of efficiency with pressure, at rated volume.

7 This latter curve shows graphically the variation of pressure with change of speed, which follows the law of squares; that is, doubling the speed gives four times the pressure, etc., from which it will be seen that only moderate changes in speed are necessary to give considerable changes in pressure. It is these changes in speed, increasing or decreasing the blast pressure, which are utilized to main-

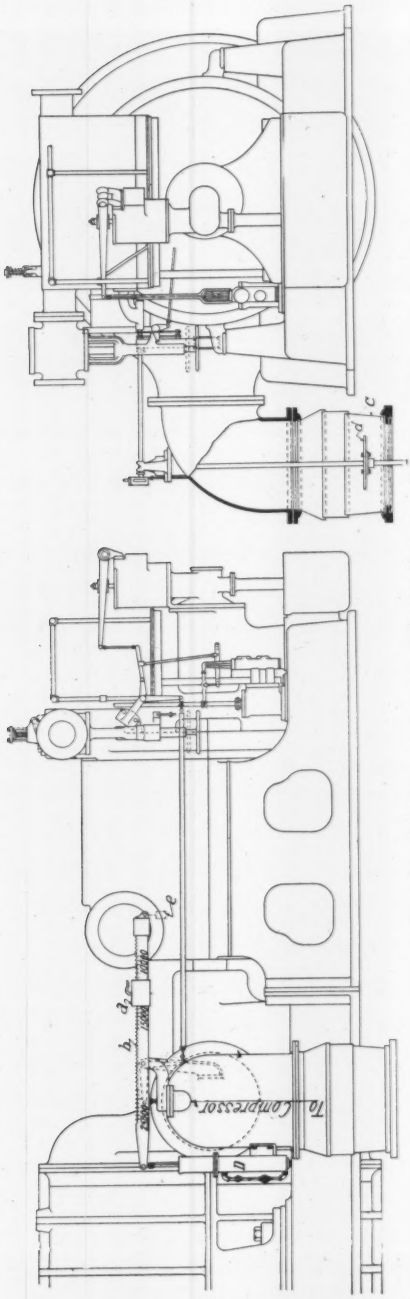


FIG. 3 VIEW SHOWING CONSTANT-VOLUME GOVERNOR

tain a constant rate of flow of air into the furnace, against the varying resistances set up in the tuyeres and furnace by varying furnace conditions; as, for instance, clogging of tuyeres and changes in the size and composition of the charge, temperatures, etc.

8 The means by which these changes of speed are produced in the manner necessary to keep up a constant rate of influx of air per minute is shown in Fig. 3. This shows a steel disc *d* sustained on the inflowing air current within a conical enlargement of the inlet pipe. By means of the sliding weight *a*, the resistance of this float and displacement by the air current is adjusted in accordance with a scale on the scale beam *b* which is graduated accurately in cubic feet per minute to read volumes of free or atmospheric air. By setting this weight at the graduation corresponding to the rate of discharge of air desired, the disc is caused to assume a position in the conical enlargement *c*, which results in supplying steam to the turbine in quantity sufficient to establish the proper speed of the compressor and pressure of blast to cause the required flow of air through the furnace. In case the rate of air flow tends to decrease, the disc *d* sinks to a lower point in the enlargement *c*, since the supporting air current decreases its sustaining power. More steam is by this admitted to the turbine and the speed is increased, resulting in increase of pressure, and this increased pressure reëstablishes the desired flow of air. In case too much air tends to flow into the furnace, the reverse of all these effects takes place. In practice, the operation of this device is most regular and satisfactory.

9 This method of governing, by the indications of a properly calibrated scale beam, gives an entirely new instrument, which, in the hands of a skilled furnace manager, will undoubtedly enable improved results in furnace operation to be obtained, since an accurate knowledge of the amount of air supply is always at hand by this means.

10 Such knowledge cannot be obtained from reciprocating blowing engines, since the expansion of air in clearance spaces causes an error increasing in amount as discharge pressure increases, and because leakage increases with increase of discharge pressure and the slip is a variable and uncertain amount. On the contrary the air governor is unvarying in its action, and will not change its indications with time, since wear and leakage are absent.

11 It has been intimated before that this is a variable-speed apparatus. In normal blast furnace operation pressure may vary from 10 to 20 lb. per sq. in. These pressures require speeds in the particular apparatus under description of about 1500 for 10 lb. pres-

sure to 1800 for 20 lb., as appears on the curve, Fig. 2. The blast furnace operator therefore instructs the engineer operating the compressor not to maintain a certain number of revolutions, as is customary with reciprocating engines, but to set the scale beam weight for the required volume in cubic feet per minute.

12 The graduation and calibration of the scale beam in cubic feet per minute is determined during the shop test of the apparatus before shipment by accurate tests with standard orifices and pitot tubes and these graduations are accurate within about two per cent.

13 A simple oil dashpot *D*, Fig. 3, attached to the scale beam, prevents any racing or undue fluctuations of speed.

14 In operating the blowing unit, it is only necessary to manipulate the hand throttle valve in the main steam pipe when it is desired to bring the compressor to rest. At all other times control is effected through the scale beam, with wide-open throttle. At times of checking the furnace or casting, the weight *a*, Fig. 3, is moved to the extreme end of the scale beam at the position indicating the minimum volume for which the scale beam is graduated, and still further decrease of speed and pressure is produced by adding an auxiliary weight at this end of the beam or by depressing it by hand. On removal of the auxiliary weight and replacement of the sliding weight *a*, at the running volume graduation, the compressor speeds up until the volume required is obtained. This manipulation is in practice of the simplest character.

15 The air governor acts upon the pilot valve of the hydraulic valve gear commonly used on the larger sizes of the Curtis turbine, through a system of floating levers, in such wise that when the turbo-compressor nears the maximum speed for which it is designed, in this case 1950 r.p.m., a centrifugal governor of the usual type comes into action and keeps the speed at this maximum as long as the resistance to air flow in furnace or tuyeres remains so high that the volume of air, for which the air governor is set, cannot be forced through at the maximum pressure to which this speed corresponds, in this case 25 lb. per sq. in. During this period the air governor is out of control of speed, but it comes into action immediately when the furnace resistance decreases.

16 In case of breakage or sticking of the governor mechanism which permits the speed to exceed 1950 r.p.m., an emergency governor mechanism, entirely independent of the mechanism previously described, comes into play and closes the main throttle valve, bringing the compressor to rest.

17 In all high-speed apparatus the certainty of the oil supply is an important feature and it is particularly so in this service. In this unit there are three shaft bearings requiring automatic lubrication, and this is furnished by a valveless gear pump, worm-driven from the main shaft, which circulates oil under 15 to 25 lb. pressure. The same pump also supplies this necessary oil to the hydraulic cylinder which actuates the valve gear. The oil is returned from bearings and cylinder to a tank where it is settled and strained before re-use. In order to guard against any stoppage of oil circulation, an alarm is provided which causes a steam whistle to blow in case the oil pressure falls to 5 lb. per sq. in.

18 The oil is cooled in the bearings at the point where the heat is generated, by means of water-cooled coils embedded in the bearing linings.

19 The apparatus described uses, of course, high-pressure steam. Obviously the compressor is adapted equally well to the use of low-pressure turbines as to drivers and so driven affords a ready means of increasing the efficiency of existing plants containing reciprocating blowing engines, by the usual method of exhausting from the reciprocating steam cylinders into the low-pressure turbine. The governing by volume of air discharged is equally applicable here, and all the advantages of this system can therefore be realized.

20 Increased efficiency of the plant to the extent of 20 per cent to 50 per cent may be thus realized with a very moderate addition to the cost.

21 The installation at the Empire Iron & Steel Company, which the photographs accompanying this article represent, was put in operation on the furnace on March 8, 1910, and has been in continuous operation ever since. At the time this apparatus was put in operation, it was not expected that the volume of air required by the furnace would be at such a low figure as turned out to be the case, the machine having been designed for a normal volume of 22,500 cu. ft. per min. On putting the machine on the furnace, it was found the volume required was only about 15,000 cu. ft. per min. and the pressure corresponding to this volume under furnace conditions ranged from 10 lb. to 12 lb. Under these conditions, it was found that pulsations were met with in the pressure line, this pressure fluctuating about 2 lb., and in order to overcome this pulsation it was found necessary to throttle the inlet opening. Fig. 4 shows the character and magnitude of these pulsations. Since this time, a convenient butterfly-valve throttling mechanism has been designed and

applied, which is found to eliminate these pulsations without appreciable loss of efficiency.

22 The pulsations in pressure above noted are an inherent characteristic of all centrifugal blowing apparatus of similar construction, and they occur when the apparatus is operated at loads and pressures widely differing from those for which the apparatus is designed; that is, from normal full volume and pressure. At any given volume they occur at a certain critical pressure and at all higher pressures, but do not occur at lower pressures than the critical. As volume is increased, critical pressure increases also. The critical pressure is slightly affected by the density and the humidity of the air.

23 Fig. 5 gives the characteristic critical pressure-volume curve of this compressor.

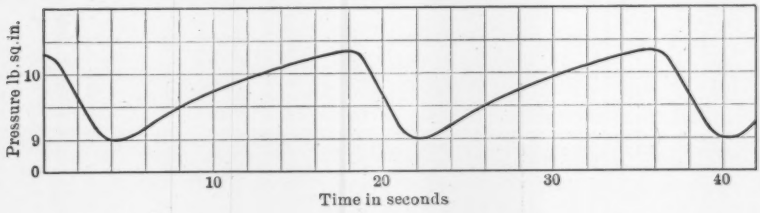


FIG. 4 PRESSURE CURVE DURING PULSATIONS

24 The rate and extent of the pulsations are affected by the capacity of the discharge piping, stoves, etc., into which the air flows. The larger the capacity the longer the period or wave length and the greater the wave magnitude, and vice-versa. The diagram in Fig. 4 shows the pressure waves from the machine installed at Oxford Furnace. When tested in the shop with very short piping of small capacity, the wave length was only a second or so, and of very small height.

25 The pulsations occur only at such loads that the characteristic pressure curve of the apparatus is rising with increase of volume or remains horizontal, and the effect of the throttling is to superpose a drooping pressure curve, falling with increasing volume, which alters the shape of the resultant pressure curve and makes it droop also. As the throttling required to remove entirely such pulsations is only a few inches of water, it has no appreciable effect on the efficiency of the compression.

26 Fig. 6 is the curve of pressure and volumes for this compressor at *constant speed.*

27 At the time this was written the blast pressure at Oxford Furnace varied from 10 lb. to 14 lb. during the day with volume constant at 16,000 cu. ft. per min. The speed varied from 1500 to 1600 r.p.m. The average steam pressure was 135 lb.

28 The figures in Table 1 are taken from a typical station log, showing the variation of pressure and volume during the 24-hr. period of operation.

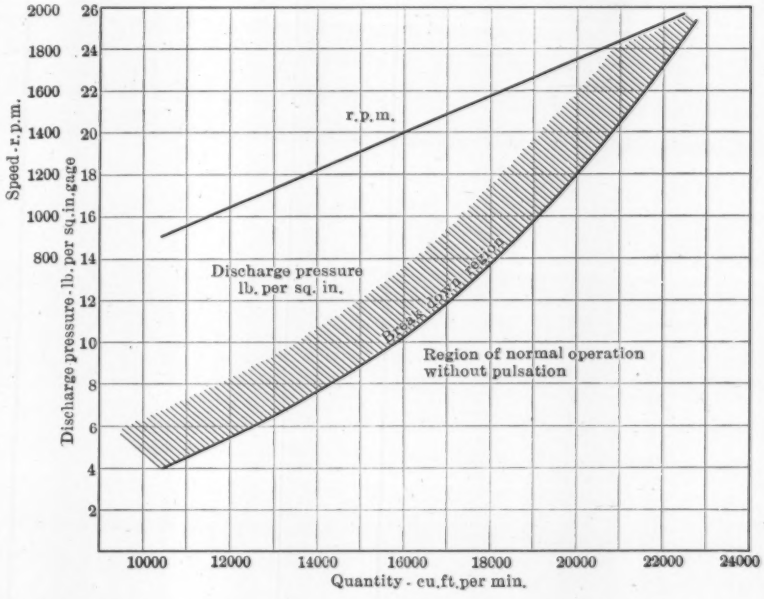


FIG. 5 CURVE OF BREAKDOWN POINTS FROM FACTORY TESTS. PRESSURE AND R.P.M. PLOTTED AGAINST CU. FT. PER MIN.

29 The apparatus used for blowing the furnace before putting this machine into operation consisted of two vertical reciprocating blowing engines built by the I. P. Morris Company, each of the following dimensions: Steam cylinder diameter, 54 in.; blowing cylinder diameter, 72 in.; stroke, 72 in. Blowing cylinder displacement, 339 cu. ft. per revolution each. Maximum speed rating, 30 r.p.m. each, giving 20,300 cu. ft. per min. total displacement. Actual maximum

speed, 23 r.p.m. each, giving 15,000 cu. ft. per min. total displacement. The average blast pressure was 8 lb.

30 Judging from the revolutions of this engine, it was thought that the volume used was about 14,500 cu.ft. On putting the centrifugal compressor into action, an immediate increase in the amount of iron melted by the furnace was experienced. The output went up from an average of 139 tons per 24 hr. in February 1910, to 176 tons in April 1910, and the iron was found to be of a more uniform character and the operation of the furnace was improved. A gradual increase in the amount of air has since taken place and the corresponding increase in pressure required to force the air through the furnace has

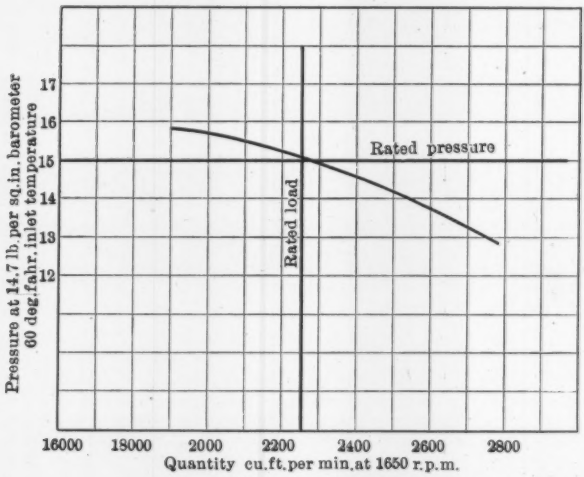


FIG. 6 FACTORY TEST, SHOWING PRESSURE PLOTTED AGAINST QUANTITY OF AIR. 1650 R.P.M.

been necessary as was to be expected. This increase of air has resulted in an increase in the production of the furnace from 176 tons on starting to the present average of about 190 tons. The machine is now operating with 16,000 cu. ft. of air and the production of ore is 185 tons per 24 hr. average. It is proposed to continue this increase to 200 tons per 24 hr., the limit of the charging apparatus.

31 The dimensions of the furnace are as follows: Diameter at bosh 17 ft. 6 in.; at hearth 11 ft.; at top throat 12 ft.; height from hearth to dumping ring 80 ft.

32 The condensing apparatus is of the barometric type, and the injection water is supplied by a turbo-driven centrifugal pump, placed

in the sub-basement; and at the outset when the machine was first put in operation, difficulty was encountered with the condensing water supply, which made it necessary to operate the machine for a considerable period of time non-condensing. Owing to the unfamiliarity of the fire-room force with the new boilers which had been installed it was even necessary to operate with steam pressures as low as 60 lb. per sq. in. gage for various periods, under which conditions the compressor set operated with entire satisfaction.

TABLE 1 ENGINE ROOM REPORT, MARCH 17, 1910

EMPIRE IRON & STEEL COMPANY, OXFORD FURNACE, N. J.

Time	Volume, cu.ft.	Blast Pressure, lb.	r.p.m.	Steam Pressure, lb.	Vacuum, in.
a.m.					
1	15750	13	1540	140	24
2	15750	12.5	1490	135	25
3	15750	13.5	1580	135	25
4	15750	12	1510	140	24
5	15750	13.5	1530	155	24
6	15750	13	1550	150	25
7	15750	12.5	1550	150	25
8	15750	12	1490	120	h.p.
9	15750	11.5	1500	130	h.p.
10	15750	13.5	1580	160	26
11	15750	12.5	1520	155	26
12	15750	12.5	1500	150	26
p.m.					
1	15750	13	1530	140	26
2	15750	12	1490	150	26
3	15750	13	1560	130	26
4	15750	13	1560	150	26
.5	15750	11	1445	145	26
6	15750	11.5	1450	130	26
7	15750	11	1490	135	26
8	15750	13	1510	140	26
9	15750	12.25	1500	155	25.5
10	15750	11	1383	140	25
11	15750	11.5	1410	150	25.5
12	15750	11.5	1440	145	25

Made 208 tons of iron in 24 hours.

33 Owing to the fact that the condensing apparatus is of the barometric type, the further fact that the machine is operating far below its designed capacity and the difficulties involved in making an accurate boiler test to determine the amount of feed water under present conditions, no tests have been made to determine the actual efficiency of the machine. It is, however, furnishing considerably more air than the old machines, as is evidenced by the greatly increased product of the furnace, and is at the same time operating with fewer

boilers. Also these boilers are more easily worked than when operating with the engine.

34 There is great difficulty in making comparisons of the performance of this type of blowing unit with reciprocating types, either steam or gas driven, owing to the absence of actual test figures, since none have been published which permit of accurate and satisfactory comparison. With the results which have been obtained from all sources as to the actual performance of such machines and from actual experience with this machine and its sister machine installed at the Northern Iron Company, in line with tests which have been made in the factory, it seems that the following conclusions are correct in reference to this apparatus as compared with reciprocating engines for blowing blast furnaces:

a That the output of the furnace is increased on account of the greater steadiness of operation and more uniform conditions obtaining in the furnace.

b That the quality of the product is improved.

c That the steam consumption is equal to, or less than, that of the best compound engines blowing similar furnaces.

d That the engine room space occupied is only a fraction of that needed by reciprocating engines, either steam or gas.

e Considering all factors, including consumption of fuel; cost of operation, including oil and supplies, attendance, etc.; cost of buildings and foundations, interest on the investment; and cost of maintenance of plant; that the centrifugal compressor is a blowing apparatus which can be operated for a lower net cost than any other means of blowing furnaces.

THE PURCHASE OF COAL

By Dwight T. Randall

ABSTRACT OF PAPER

Most boiler rooms are now conducted in a manner which permits of considerable saving along two lines: (*a*) the selection of a coal which is suited to the plant and at the same time is capable of delivering the greatest amount of heat to the boiler for a unit of cost; (*b*) burning the coal by approved methods to obtain the highest practical efficiency.

The coals which are offered in almost any market vary in price and in quality to an extent which justifies a careful study of their character and heating value in order to determine which coal will prove most economical when the equipment, the load conditions and the price are considered. A coal which is entirely satisfactory in one plant may be unsuited to another.

It is possible to burn almost any fuel with reasonably good efficiency provided the furnace is properly designed for the particular fuel to be burned.

Coals which are suitable for any given equipment depend for their value principally upon the B.t.u. and the size of the coal. A thorough study of coals and the variations in their quality has naturally led to the purchase of coal under specifications with a guaranteed analysis, which provide for a definite procedure in case of a variation in the quality of coal delivered.

THE PURCHASE OF COAL

By Dwight T. Randall, Boston, Mass.

Member of the Society

Large savings may be made in the boiler room along two distinct lines: first, by burning the fuel at the highest practicable efficiency; second, by choosing fuel of a character suited to the plant conditions and equipment and which at the same time will develop the greatest amount of heat for a unit of cost. Each locality and each kind of equipment presents a different problem for solution.

VARIATIONS IN THE QUALITY OF COAL

2 The coals of the United States vary widely in their character, some being high in fixed carbon and low in moisture, volatile matter and ash, while others are low in fixed carbon and high in other constituents. Moisture is an inherent constituent of the coal and an increase in its percentage decreases the heating capacity of a given coal proportionately. This constituent is weighed and paid for on an equal basis with the combustible portion of the coal, and therefore this determination is of considerable importance in ascertaining the value of coal.

3 An analysis reported "as received" represents the composition of the coal just as it is delivered at the laboratory. An analysis reported on the "dry basis" represents the composition of the coal after having been dried for one hour at 105 deg. cent. in a special oven. Coals containing low percentages of volatile matter may be burned in ordinary furnaces with good results, but those with high volatile matter give off large quantities of gas and are difficult to burn with economy and without smoke except in furnaces which are specially designed.

4 The ash in coal is, like moisture, an inert constituent. The ash may be present in the coal in small particles distributed in such a way as to make it impossible to separate it from the coal, or some of

it may be present in larger pieces which, owing to a lack of care in mining and preparation, are often found in the coal as it comes to the market. Not only does the percentage of ash in coals affect their value, but the nature of this ash may influence the efficiency with which coals are burned. Increased percentage of ash also decreases the heating value proportionately and causes additional expense and loss in efficiency due to extra labor required to handle this ash, both on the grates and when it is removed. The fusibility of ash governs the percentage of clinker that will be formed from any type of coal and consequently some attention should be given to this feature. Sulphur is found in varying percentages and is generally considered an undesirable element.

5 The B.t.u. or heating value of coals of any given type determine directly their value as fuels. When coals of the same character are under consideration the heating value may be considered as a correct measure of the value of the coal. When coals of different character are to be compared, the character of the coal as well as the heating value must be considered.

6 There is often a considerable variation in the quality of coals from the same district. This is due principally to the impurities which are found in the coals. Mines that are working the same bed of coal at points which are near each other often deliver coal having different values on account of variations in the coal itself or in the methods of mining and preparing the coals for the market.

7 On account of economy in mining and in marketing coal, it is a very common practice for one company to operate a number of mines and to ship coal from all of these mines to their customers. It is only rarely that coal is equally good in all the mines and, therefore, the customer will receive some good coal and some inferior coal. This is also true of the coal which is sold in barge lots. A large number of carloads of coal are required to fill the barge and it is not practicable in many cases to furnish the coal from one mine.

8 Some coals may be burned at high or low rates of combustion without difficulty and with good efficiency, but there are many coals which always give trouble from clinker when burned at high rates of combustion. When burned at moderate rates they may usually be fired so as to give the same percentage of heat to the boiler as the non-clinkering coals.

RELATION OF QUALITY TO RESULTS

9 The influence of the volatile matter on the efficiency depends on the design of the furnace. With a poor furnace and indifferent firing the coals containing about 18 per cent volatile matter may give results 10 or 12 per cent higher than coals containing 30 per cent or more volatile matter. With furnaces adapted to the kind of coal burned there is but little loss of combustible gas.

10 The ash in the coal affects the heating value to some extent as there is a loss of both time and heat while the fires are being cleaned and the presence of large quantities of ash interferes with the proper distribution of air through the fuel and may lower the efficiency.

11 The moisture not only requires heat to evaporate it into steam, but if the coal is very wet and is fired in large quantities, it may cool the bed of fire and cause an additional loss of unburned gas.

12 The size of coal is important in many cases. If the coal does not coke and is fine, there may be a large loss of fuel through the grates when burned on inclined grate stokers or on hand-fired grates at rates that require frequent breaking up of the fuel bed. The size of the coal also affects the economy with which it may be fired. If coal is too large more air is admitted than is necessary to burn it properly and if the fuel bed can not be increased in thickness to overcome this difficulty, there will be a large heat loss. If the coal is fine and the draft is very strong, some of it will be carried off the grate only partially burned. This is frequently the case when the coals are fine and light and the boilers are forced.

13 Fine coal which cakes and forms a porous coke may be burned with good efficiency. If the coal does not coke but packs closely on the fuel bed, it is difficult, if not impossible, to secure a uniform air supply at all parts of the bed and the combustion is poor owing to an excess of air at some points and a lack of air at others.

14 Fuels considered without reference to any particular equipment may be valued on the basis of their available heating value. It has been found possible to design furnaces to burn almost any fuel with reasonably good efficiency when based upon the available heat of the fuel. This has been accomplished with tan bark, sawdust, lignite and low grade coals. As a rule inferior coals can be bought much more cheaply on their heating value than the higher grades of coal and it is to the interest of every consumer to select the coal which will give the greatest amount of heat from a unit cost, provided it can be burned successfully in his plant. In many cases it will be

profitable to change the equipment so as to burn slack coal or coals which are below the average quality. It is fully as important to take into account the size and character of coal when automatic stokers are in use as when the coal is hand-fired.

15 The same intelligence should be used in selecting coal for a given use as is required in selecting steels for manufacturing purposes. Some of the most progressive users have been aware that there was a considerable difference in the quality of the coals used in their plants and have generally decided that the chemical analysis, with determinations for heating value, is the best basis on which to establish a standard.

16 The methods employed in burning the coal are of equal importance with the quality and should be given careful attention. The coal dealer should not be held responsible for results in boiler plants except as influenced by changes in the quality of the coal delivered. A coal which is suited to one plant may not burn well in another, owing to differences in equipment, load condition or to the methods of handling the fires.

17 The advantages of knowing accurately the quality of coal which is being burned in a power plant and whether any changes in the coal consumption are due to the coal or to the method of operating the plant, have led a number of managers to make analyses of all the coal delivered to their plants. After following the deliveries in this way for a year or more, these men have as a rule decided to place their contracts with the understanding that if the coal delivered can be prepared so as to eliminate more of the impurities, they will pay a higher price, and if the coal is below quality they will deduct from the regular price in accordance with the quality of the coal.

18 Immediately on considering the purchase of coal on a guaranteed analysis the question as to how the sample shall be taken and by whom it shall be analyzed is raised. The method of taking a sample of coal is fully as important as the manner in which it shall be analyzed and the cause of doubt as to the value of coal analyses has been largely due to ignorance or carelessness in taking samples for analysis. It is only fair to both parties concerned that the sample should be taken in the manner which will secure a small portion which is thoroughly representative of the entire lot. A method has been quite generally adopted and experience has shown that when two samples are taken in accordance with these approved methods the results are within reasonable limits of accuracy.

METHODS OF SAMPLING

19 The following method of obtaining a sample of coal has been used by a number of different firms and has been found satisfactory. The main object in taking a sample of coal is to secure a small portion of the coal which represents as nearly as possible the entire shipment or delivery.

20 The original sample should preferably be collected in a large receptacle with cover attached, by taking small shovelfuls from many parts of the car, barge or vessel as it is being unloaded, or from as nearly all parts of a pile as possible, care being taken in all cases to secure practically the same amounts from the top, middle and bottom of the coal. The original sample thus taken should amount to 500 lb. or more, preferably 1000 lb. to 2000 lb. A separate sample should be taken from each 1000 tons or less delivered. The gross sample thus collected should contain the same proportion of lump and fine coal as exists in the whole shipment. It should be protected from the weather in order to avoid gain or loss in moisture and should be immediately quartered down to a smaller sample, according to the following method.

21 The large lumps of coal and impurities should be broken down on a clean, hard, dry floor with a suitable maul or sledge. The coal should be thoroughly mixed by shoveling it over and over and formed in a conical pile. The pile should then be quartered, using a shovel or board to separate the four quarters. Two opposite quarters should then be rejected and the remaining two broken down to a smaller size, mixed and re-formed in a conical pile and quartered as before. This process should be continued until the lumps are $\frac{1}{4}$ in. in size or smaller and a one or two-quart final sample remains. *All* of this final sample should immediately be placed in one or more glass or metal cans and sealed air tight. The following table gives the largest sizes allowable in the samples of various weights and the coal should preferably be broken into still smaller sizes before quartering:

Weight of Sample	Should Pass Through
1000 lb. or over	$1\frac{1}{2}$-in. sieve
500 lb. or over	$1\frac{1}{4}$-in. sieve
250 lb. or over	1 -in. sieve
125 lb. or over	$\frac{3}{4}$-in. sieve
60 lb. or over	$\frac{1}{2}$-in. sieve
10 lb. or over	$\frac{1}{4}$-in. sieve

22 The sample should be worked down as rapidly as possible to avoid loss of moisture through exposure to the air. The outside of the can should be plainly marked and a corresponding description placed inside the can.

23 The following data should accompany the sample:

Coal delivered to.....
Sampled by.....Date.....
Amount taken for original sample.....
Amount of coal sample represents.....
Sampled from barge, car or pile.....
Car (initial and number).....
Barge or vessel.....
Trade name of coal.....
Grade (¾, slack, nut, run of mine, etc.).....
Remarks (appearance of coal, lumps, slate, sulphur balls, weather conditions, etc.).....
Sold by.....Mined by.....
County.....State.....Mine.....

ACCURACY OF SAMPLING

24 It is difficult to make the average man understand the importance of the sample and the influence of the method of sampling on the results. The methods and care used in breaking down and quartering the sample are very important.

25 Some figures are submitted to illustrate this point. An experienced sampler was instructed on three occasions to take samples of coal from a barge and to take a duplicate sample from the opposite quarters in addition to the regular sample. Analyses of these samples (Table 1) showed that the results were well within reasonable limits for the combined error of sampling and testing.

TABLE 1 ANALYSES OF DUPLICATE SAMPLES BY EXPERIENCED SAMPLER

	Sample No. 1		Sample No. 2		Sample No. 3	
	No. 1A	No. 1B	No. 2A	No. 2B	No. 3A	No. 3B
Weight of sample, grams	958	830	864	680	832	827
Ash in dry coal	7.80	7.75	7.98	8.16	7.62	7.57
Sulphur	0.98	0.93	0.92	0.87	0.90	0.92
B.t.u.	14,539	14,528	14,478	14,423	14,549	14,600
Difference		11		55		51

26 To illustrate the results of careless preparation the following data are submitted. A man with but little experience in sampling coal, but who had been instructed as to the proper methods was told to sample about 500 tons of coal and on making the final quartering to place each of the quarters in separate cans. These cans were then sent to the laboratory with the results shown in Table 2.

TABLE 2 ANALYSES BY INEXPERIENCED SAMPLER

	Portion 1	Portion 2	Portion 3	Portion 4
Weight of sample, grams	722	856.5	1231	1508
Ash in dry coal	6.71	7.26	6.87	8.11
Sulphur	2.11	2.49	2.27	2.99
B.t.u.	14,690	14,558	14,688	14,428

27 It should be noted that this did not conform to the usual practice of taking two opposite quarters to be combined for the final sample of the coal. The portions taken were not even quarters, the last being nearly twice as large as the first. The results show that the final sample was not properly mixed to secure an even distribution of the coarse and fine particles through the pile and that it was carelessly quartered. Evidently some of the results are too high and others too low. By multiplying the B.t.u. value by the weight of each portion and determining the average for the entire final sample, it is found to be 14,571 B.t.u. The B.t.u. values are, therefore, above or below average, as follows:

	Portion 1	Portion 2	Portion 3	Portion 4
Variation	+119	−13	+117	−143

28 If such careless methods will give results within these limits one can surely depend upon careful preparation to give results within less than one-half of 1 per cent of the value of the coal. In support of this statement, the following facts are submitted.

29 The accuracy of this plan has been demonstrated in several instances when samples have been taken from the same lot of coal at the same time by a representative of the coal company and by a representative of the consumer. In one case more than 1000 tons of coal delivered from a barge were so sampled and analyzed and the representative of the consumer obtained results showing 8.75 per cent ash, while the representative of the coal company secured results showing 8.73 per cent ash in the coal.

30 On one occasion a coal consumer made a complaint to his

dealer about the coal which had been delivered. A representative of the dealer took a sample from a pile according to accepted methods. Later on a disinterested party was employed by the consumer to sample and test the same coal. The analysis of the first sample showed the ash in the dry coal to be 7.47 per cent. The second sample, when analyzed, was found to contain 7.49 per cent ash in the dry coal. The difference in the heating value of these two samples was 38 B.t.u. on the dry basis. These are remarkably close checks but many other instances show that samples properly taken may be expected to check within about one-third of 1 per cent of ash in the dry coal.

31 At another time coal from the same barge was sampled by both the consumer and the dealer with the following results:

	Sample Taken by Representative of Consumer	Sample Taken by Representative of Coal Dealer	Difference
Ash in dry coal	10.48	10.14	0.34
B.t.u. in dry coal	14,099	14,155	56

32 Another case shows that these methods will secure results which check reasonably well when samples are properly taken and that the results are not always as unfavorable to the coal dealer as they frequently assume. A coal dealer employed a disinterested party to sample coal from a barge as it was unloaded and a sample was taken by the consumer at his plant for one week. These samples were worked down and analyzed by separate laboratories with the following results:

	Sample No. 1 Taken by Representative of Coal Company	Sample No. 2 Taken by Consumer	Difference
Ash in dry coal	5.96	5.67	0.29
B.t.u. in dry coal	14,803	14,866	63

33 Such results can be obtained only when samples are taken and prepared for the laboratory by careful men who will follow instructions absolutely. It takes time to break down a sample properly and few laborers who are detailed to do this work realize the importance of the work, and a short or easy method is frequently used which may secure results far from right.

34 The fact that there may be small variations from the true heating value just as there may be in weight of the coal and that these variations are as fair to the buyer as to the seller, must be recognized. They will tend to offset each other during a period of a year. It is better to know within one per cent of the weight and of the heating value of coal than to have no information about it. It is possible to determine both with greater accuracy if only reasonable care is used.

35 Experienced fuel engineers and chemists are quite generally agreed that a sample of coal, taken by an approved method and analyzed by an experienced coal chemist, should show results which, when compared with the true values, are within the following limits:

Moisture	1.00 per cent of the coal as delivered
Ash + or −	0.50 per cent of the dry coal
Sulphur + or −	0.10 per cent of the dry coal
B.t.u. + or −	1.00 per cent of the dry coal

36 When samples are taken in a proper manner, the results will be sufficiently accurate for all commercial purposes and are within the limits which are found in the comparatively simple operation of determining the weights of the coal shipped. It is hardly worth while to adopt more costly methods of sampling coal in order to secure a greater accuracy, until the methods of weighing coal are improved and the accuracy of the weights guaranteed within less than 1 per cent.

THE SELECTION OF COAL

37 The problems of purchasing a supply of fuel for any given plant, so as to obtain a coal that is suitable for the equipment in use and one that will deliver the greatest amount of heat to the boiler for each dollar expended, is one which requires experience and an intimate knowledge of various kinds of equipment for burning coal, and also of the different characteristics of the coals available at reasonable freight rates.

38 The following information should be considered by the engineer in deciding on the best coal for a plant:

a Kind and size of boilers and furnaces
b Load conditions, average and maximum loads
c Draft available and how controlled

d Character of the coals offered or available
- (1) Moisture and its effect on weight of combustible matter delivered
- (2) Volatile matter and its relation to kind of furnace
- (3) Ash: its amount and its fusibility and tendency to clinker
- (4) Sulphur: the amount and how combined
- (5) Heating value in B.t.u.
- (6) Coking qualities of the coal

e Size of the coal
- (1) Relation of the size of coal to the equipment

SPECIFICATIONS FOR COAL

39 After it has been decided what kind of coals may be burned successfully in any given plant, it is important that the specifications be so drawn that it will be to the interest of the dealer to deliver the kind of coal which has been established as standard in his proposal and prevent the substitution of lower grades of coal which might be difficult to burn with good results. It is evident that a specification based on heating value alone will not do this and that there should be some clause making it possible to reject the coal, or to burn it and pay for it at a reduction in price greater than that due to B.t.u. only.

40 There has been a great deal said for and against the plan of purchasing coal on a guaranteed analysis and, as is often the case, both sides are right but they are really discussing different things.

41 A properly drawn specification protects the dealer who is prepared to furnish good coal in competition with dealers handling inferior coals at the same price. Where these specifications permit the coal contractor to state the analysis of his coal which on acceptance of the bid becomes the standard for the contract, there need be but little variation in the price if the dealer is familiar with the analysis of the coal offered, and if the standard is based on average values the premiums and penalties for the year should practically balance each other. Many dealers have bid on impossible analyses and then blamed the specification plan for their losses.

42 A properly drawn specification providing for premiums for better coal than that specified, encourages the coal operators to exercise greater care in mining and in picking the coal before shipping, and enables them to secure a return on the cost of such preparation. Most consumers have found that it is not profitable to pay freight on an unnecessary amount of slate and ash in the coal.

43 The important items in a specification are as follows:

a A statement of the amount and character of the coal desired.

b A statement regarding the conditions for delivery of coal.

c A statement regarding the disposition which will be made of the coal in case it is outside the limits specified.

d A statement regarding the corrections in price for variations in heating value, for variations in ash and for variations in sulphur, provided it is found advisable to limit the percentages of ash and sulphur in the coal to be delivered.

e A blank form on which the dealer may submit price and the kind and quality of coal which he proposes to furnish.

44 There are several forms which have been prepared along these lines which have proved satisfactory. It is necessary in almost every case to modify the specifications to fit the special conditions in the plant and the fuels which are available.

45 In the past many dealers not familiar with the quality of the coals have bid on contracts and guaranteed a quality of coal that was better than can be delivered from any mine in the United States. Naturally these analyses that had been useful as exhibits were found to be poor standards on which to base the guarantees of coal to be delivered. Many progressive dealers have recognized the reasonableness of the demand for a standard for quality of the coal to be delivered and they are selling coal on a basis which secures for them the average price they expect to get for the coal.

46 The importance of testing coal purchased under contract may be illustrated by two recent cases. In Case 1 the coal was guaranteed to be Georges Creek and in Case 2 to be New River (Table 3).

TABLE 3 DATA OF COAL PURCHASED UNDER CONTRACT

	Case 1		Case 2	
	Guaranteed Analysis as Delivered	Coal Delivered	Guaranteed Analysis as Delivered	Coal Delivered
Ash in dry coal	8.00	12.66	6.00	8.48
B.t.u. in dry coal	14,250	13,558	14,700	13,981

47 Neither of the parties in the above cases had made a practice of having the coal which was delivered at their plants, sampled and analyzed. In such cases the blame for paying a good price for a poor coal rests with the purchaser. The dealer probably knew as little about the quality as the man who paid for it.

48 The plan of purchasing coal on a specification based on a guaranteed analysis may or may not be a good one, depending on circumstances. It has proved satisfactory in nearly every case when the specifications were so drawn as to protect the buyer against substitution of other coals and at the same time was perfectly fair to both the buyer and to the seller. Such specifications actually protect the dealer against unfair competition as has been shown in many cases. This plan will not be satisfactory if the specification is carelessly drawn and the coal is selected on the basis of price without regard to its adaptability to the furnaces; nor will it prove satisfactory if the sampling is done by ignorant or careless men and the analysis made in poorly equipped laboratories by inexperienced chemists. Whether it will be advisable to purchase for a plant on this basis depends on the amount of coal used, the amount delivered at one time, the kinds of coal available and whether the purchaser and the dealers are qualified by a knowledge of the available coals to enter into a contract on this plan.

SUMMARY

49 There is a wide difference in the character of the various coals on the market and a considerable variation in the quality of the coals sold under the same general trade name. These differences make it difficult to secure the most enonomical coal for a given plant without an intimate knowledge of the coals and of the engineering problems connected with their combustion.

50 Careful investigations have shown that if coals are suited for use in the furnaces installed, they may be burned with practically the same efficiency and are of value in proportion to their heating values. Investigations have also shown that almost any fuel may be burned in suitably designed special furnaces so as to give results which are nearly proportional to their available heating value. In many cases it has been found advisable to change furnaces to utilize a low-grade fuel rather than to purchase an expensive coal for the existing equipment.

51 The management of any plant should know the quality of the coal in use and be able to locate the cause of variations in the boiler room economy. Poor results are not always chargeable to the coal. Operating conditions are frequently at fault. An analysis of a representative sample of coal which is suitable for the furnaces is a more

accurate measure of the value of the coal than the performance of the boilers.

52 This method of purchasing coal has already been adopted by many of the larger and most progressive consumers of coal. Its advantages are so clearly demonstrated to engineers thoroughly experienced in power house practice that few who are in a position to purchase large quantities of coal are willing to do so without a guarantee as to its quality. With information as to the coal bed, the district and the mine from which the coal will be furnished and the guaranteed analysis, an experienced engineer can select a coal for the plant which is both suitable and cheap when quality and price are considered.

53 A contract based on a guaranteed analysis provides for a definite procedure in settling for variations in the quality of the coal delivered and avoids the necessity of devoting much time to personal arguments and correspondence regarding poor coal. If both the consumer and the seller are familiar with the technical points involved in the sale of coal on a guaranteed analysis, it will prove a fair method by which the purchaser pays according to the value of the coal delivered to him and the dealer is reimbursed for any expense due to better preparation of the coal.

A REGENERATOR CYCLE FOR GAS ENGINES USING SUB-ADIABATIC EXPANSION

By A. J. Frith, Published in The Journal for July 1910

ABSTRACT OF PAPER

A new cycle of theoretically 100 per cent efficiency, caused by the expansion line being steeper than that due to free expansion, is presented in this paper, which shows that in the older regenerative cycles the loss of heat to water cooling overbalances the theoretical economy, a condition which is here avoided. How the brake efficiency, under practical conditions, may be derived from formulae, and a heat expenditure of 7000 B.t.u. be expected, with a compression pressure of only 125-lb. gage and a peak pressure of 275-lb. gage, are also described.

This means 50 per cent greater economy in fuel than is usual, say, with illuminating gas. A diagram showing the variations of regenerator efficiency with size, indicates that only practical conditions and temperatures are required to carry out the cycle. A design is shown in which no scavenging is required, no mixtures are made, and spontaneous ignition appears. While the danger of pre-ignition is avoided, the conditions for perfect combustion are coupled with light pressure and the need for ordinary good workmanship.

DISCUSSION

Sidney A. Reeve. Professor Frith's design for a regenerative four-cycle explosion-engine is a very interesting one and perhaps of real promise. It is impossible, however, to regard his explanation of its operation in so favorable a light; or, indeed, as correct at all. His theoretical argument attempts to establish a novel use of the regenerator, resulting in astonishingly high efficiency. The self-deceptive features of his argument cannot be pointed out without a brief summary of the place of the regenerator, an instrument unfamiliar to the present generation of power engineers, in heat-engine theory and practice.

All heat-engine argument necessarily starts with and is founded on the Carnot cycle. Its diagram, in the entropy-temperature field,

The American Society of Mechanical Engineers, 29 West 39th Street, New York. All discussion is subject to revision.

the only true thermodynamic field, is the simple rectangle, like *ABCD* of Fig. 10, made up of isothermals and adiabatics. This cycle, applied to steam engines, gives a very wide low diagram, like *ABCD*, Fig. 11. The objection to it is its limited height and efficiency. The secret of its great success, when approximated in the Rankine cycle *aBCD* of the actual steam-engine, is its very great width, entropy and power per unit of volume.

The Carnot cycle applied to permanent gases gives a tall narrow diagram, like *ABCD*, Fig. 12. Although highly efficient, it has always been impracticable because of its narrow width or entropy and power per unit of volume, for both the adiabatic and the isothermal expansion of air, as along *BC* and *CD*, develop tremendous volumes per heat unit handled. The combination of these two processes within a single cycle, therefore, is too much for constructive costs.

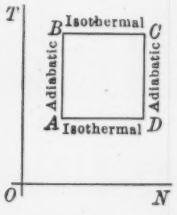


FIG. 10 DIAGRAM OF CARNOT CYCLE

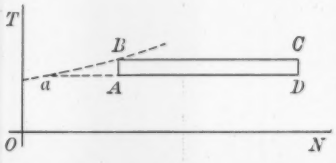


FIG. 11 CARNOT CYCLE APPLIED TO STEAM ENGINES

To avoid this trouble, and also that of Fig. 11, the regenerator was introduced. It was expected to retain high efficiencies, while avoiding excessive volumes, by eliminating adiabatic expansion. Yet Ericsson's regenerative hot-air engine of 1853, the furthest advance in that line, needed eight cylinders of 6 ft. stroke, four of them $11\frac{1}{2}$ ft. and four 14 ft. in diameter, in order to develop enough power to propel the ship Ericsson, 260 ft. long, at the speed of 7 mi. per hr. The regenerators for a much smaller engine comprised 456,000 ft. of wire to handle the heat from the combustion of $\frac{1}{4}$ ton of coal per hr.[1] What if such a machine as that did develop a horsepower from 11 oz. of coal per hr.! We could doubtless improve upon this showing today; but, even so, the promise of successful competition with non-regenerative engines is not brilliant.

A regenerative heat-engine develops, or approximates as best it may,

[1] Church. Life of John Ericsson, vol. 1, p. 188.

a diagram like *ABCD* of Fig. 13. Thermodynamically, its efficiency is the equivalent of the cycle *abcd*, or a perfect Carnot cycle, the regenerative actions *AB* and *CD* replacing the adiabatics *ab* and *cd*. For each bit of entropy received from the regenerator, as at *e*, in one cycle, having still to fall only the diminished temperature distance *ea* doing work, has already dropped usefully the distance *cf* in the preceding cycle. During the interim between cycles it has perched in the regenerator, or entropy-box, at the *e* level of temperature.

The principle of regeneration in heat-engines is to replace adiabatic temperature-change by regenerative temperature-change. If the adoption of regeneration does not eliminate adiabatic action the chief value of regeneration is gone, for we have then the burden of both processes and the full benefit of neither. Yet Professor Frith proposes to retain this combination as the soul of his new cycle.

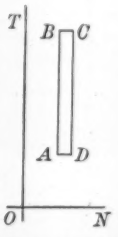


FIG. 12 CARNOT CYCLE APPLIED TO PERMANENT GASES

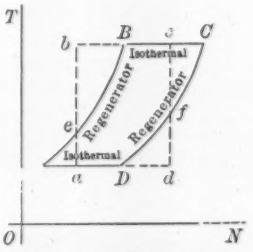


FIG. 13 CARNOT CYCLE APPLIED TO REGENERATIVE HEAT-ENGINES

Theoretically the regenerative processes *AB* and *CD* of Fig. 13 might be carried out either at constant pressure or constant volume. In practice the conditions are neither the one nor the other; the gases are displaced through the regenerator by the pistons, thus undergoing alteration of volume; and at the same time the heat handled seldom exactly equals that needed to keep the pressure constant. Similarly, *BC* and *DA* may be carried out at either constant pressure or constant volume, as long as they are isothermals. In practice they are neither; but they never depart as far from isothermals as the corresponding lines of the sub-adiabatic cycle, *BC* and *DA* of Fig. 14.

In attempting to analyze Professor Frith's proposed cycle along the argument just outlined, difficulty arises. He starts out with the ordinary gas-engine cycle, which is like none of the above, but like *ABCD* of Fig. 14. Therein *AB* and *CD* are adiabatics and *BC* and *DA* are constant-volume isomorphics. He proposes to modify this by adding

regenerative action to the adiabatic CD, altering it to Cd, and to add the heat thus regained to the combustion-process BC.

This program presents a number of obstacles, viz.:

a The heat regained from regenerative action must be taken up at, or slightly below, the temperature of deposit. Therefore the heat regained along Cd below the B level (it is proposed to carry the point d to A) can be utilized only during compression; and adding heat during compression is against every canon of thermodynamics.

b Even the heat regained above the B level, if utilized along BC, can have no other result than to increase the peak at C, resulting in its being discharged by the increased jacket action necessary to keep the engine cool. In addition, the richness of mixture requisite for sufficient speed of combustion always supplies more heat than can

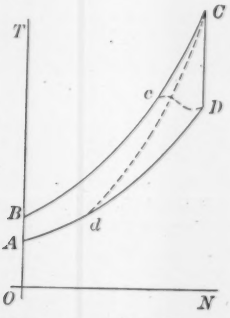


FIG. 14 ORDINARY GAS-ENGINE CYCLE

be utilized along BC. To offer the working-substance additional heat from the regenerator at this time of cycle is like carrying coals to Newcastle, or offering exhaust steam to a power house.

c The apparatus described by Professor Frith will never develop a regenerator curve like Cd, to trouble us with the above questions. Instead, it will act to drop the point C to c; that is, his regenerator space is the field of active combustion. Previous to combustion it will always be left comparatively cold by the two preceding strokes of admission and compression. Although possibly hot enough for ignition, it will be far below the temperature of explosion. Therefore, it will absorb heat greedily from the white-hot flame.

After this the flame expands somewhat in the little cylinder and then traverses the regenerator, completing its expansion in the large cylinder. In this the naturally vertical adiabatic from *c* will be distorted by the absorption of heat from the regenerator into some such path as *cD*, which will reach *D* only if the regeneration be perfect. This process *cD* is exactly the wall action of the existing gas-engine, so far as concerns the heat not carried on to the jacket water but reabsorbed during the working stroke. The importance of this action in engine-efficiency I have pointed out[1] where diagrams from actual engines quite similar to *ABcD* of Fig. 14 were presented. This wall action in existing engines frequently suffices to make the latter portion of the process *cD* virtually isothermal.

If Professor Frith's regenerator should be able to intensify this normal wall action by the presence of a vast regenerator surface, without too great incidental disadvantage, it might be of great value. The free fall of heat from *cC* to *cD* would be offset by a lessened need for jacket-water loss; but, in so far as his engine should do this, it would not be new, for I saw the general idea disclosed years ago, in papers I am not free to quote. His proposed arrangement, too, involves a regenerative interference with the processes of admission and compression which promises to be a heavy price to pay for the gain.

The form of Professor Frith's paper impresses one with the very great difficulty of thinking clearly through thermodynamic problems by means of pressure-volume notation, handled algebraically. No thermodynamic problem can be clearly understood until the essential factors, temperature and entropy, are separated from all others and portrayed clearly alone. All pressure-volume, temperature-volume, entropy-heat or other mongrel diagrams should be rigidly excluded, until the problem has been clearly stated and understood, if not solved, by entropy-temperature methods.

A. M. Levin. In view of all that has been said and proven with regard to the transformation of heat energy, it is somewhat of a surprise, at present, to have one's attention called to thermal cycles alleged to promise efficiencies ranking with the unit. Though the claims of Professor Frith with reference to his sub-adiabatic regenerative cycle may be apt to shake our faith temporarily in established axioms, they undoubtedly will not escape their due share of skepticism. Considering, however, that any hurried review of the formulae which are necessarily involved, may not generally lead to any absolute approval or disapproval of the claims set forth, I venture to

[1] Trans. Am. Soc. M. E., vol. 24, pp. 174–178, Figs. 46–51.

offer the following deductions, which it is believed will readily verify the facts of the matter.

Fig. 15 is practically the same as Professor Frith's Fig. 5 in Par. 19, though for the sake of clearness the lettering has been somewhat modified to suit the present purpose. The analytical expressions for the areas underneath the expansion lines CA and BA are

$$\text{Area } CAGF = \frac{P_c V_c}{n-1}\left[1 - \left(\frac{V_c}{V_a}\right)^{n-1}\right]$$

$$\text{Area } BAGF = \frac{P_b V_b}{k-1}\left[1 - \left(\frac{V_b}{V_a}\right)^{k-1}\right]$$

The area underneath the curve COD extended indefinitely is $\frac{P_c V_c}{k-1}$ and the area underneath the curve BA extended indefinitely is $\frac{P_b V_b}{k-1}$ while the area $CDXAC$ may be called $F^{\max.}$ per cent of the area between the lines CD and BA extended indefinitely.

In the latter part of Par. 21 we have the formula:

$$\text{Eff.}^{\max.} = \frac{\frac{P_c V_c}{n-1}\left[1 - \left(\frac{V_c}{V_a}\right)^{n-1}\right] - \frac{P_b V_b}{k-1}\left[1 - \left(\frac{V_b}{V_a}\right)^{k-1}\right]}{(1 - F^{\max.})\left(\frac{P_c V_c}{k-1} - \frac{P_b V_b}{k-1}\right)}$$

Thus

$$\text{Eff.}^{\max.} = \frac{\text{Area } CAGF - \text{Area } BAGF}{\text{Area } CDXAB - \text{Area } CDXAC}$$

$$\text{Eff.}^{\max.} = \frac{\text{Area } CAB}{\text{Area } CAB} = 1, \text{ or } 100 \text{ per cent}$$

That is, the ratio of the work realized less the energy regenerated to the total energy supplied by the combustion less the energy rejected during the expansion equals the unit.

The Eff.$^{\max.}$ expressed by the above equation is, however, not the thermal efficiency of the cycle unless the total heat rejected during the expansion, the area $CDXAC$, is absorbed by the regenerator and returned to the working charge during the compression, from A to B, without expenditure of energy. Evidently this cannot be accomplished because only that part of the rejected heat above the lower

temperature limit can be regenerated. Assuming the charge to be admitted and heated by the regenerator under atmospheric pressure, the lower temperature limit will be that corresponding to the atmospheric pressure. The energy regenerated will be the area *CODAC*, and if there is no heat loss in the regenerator the area *CODAC* = area *BAI*.

The process and the thermal efficiency ratio of the cycle are more clearly shown in the entropy-temperature diagram[1] Fig. 16. Starting from the point *I* we supply heat to the working substance by means of compression and regeneration, following the line *IB;* from *B* to *C* heat is supplied by combustion; from *C* to *A* heat is discharged to the regenerator, while the expansion follows the line *CA;* and from *A* to *I*

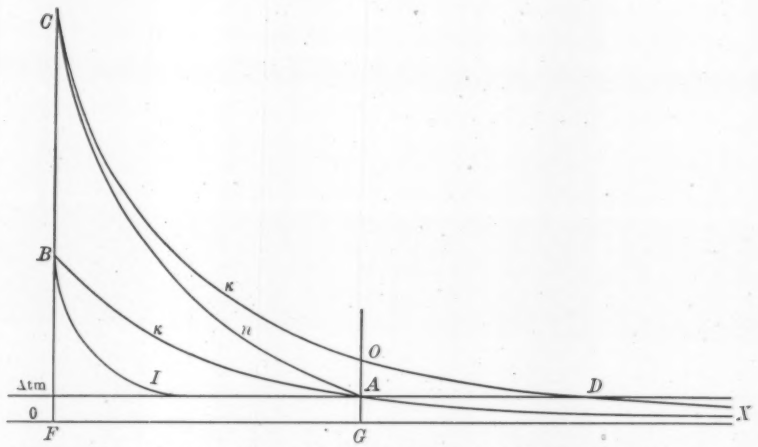


FIG. 15 SUB-ADIABATIC REGENERATIVE CYCLE (FIG. 5)

heat is discharged at a constant pressure. Hence, the net work realized is represented by the area *IBCA*. The heat discharged to the regenerator, above a temperature corresponding to the atmospheric pressure, is the area *CDA*, and the heat regenerated is the area *IBA* (Fig. 16).

Assuming the regenerator efficiency to be 100 per cent, then the area *CDA* = *IBA* and the net work realized may be represented by the area *BCDA* enclosed between the adiabatic compression line *AB*, the adiabatic expansion line *CD*, the constant-volume line *BC*, and the constant-pressure line *AD*. The heat supplied by combus-

[1] A. M. Levin. The Modern Gas Engine and the Gas Producer.

tion is the area *BCKL*, and consequently the thermal efficiency of the cycle is

$$E = \frac{\text{Area } BCDA}{\text{Area } BCKL}$$

The heat supplied during the combustion B to C is

$$Q_1 = C_v (T_c - T_b)$$

(T_b and T_c representing absolute temperatures at the points B and C) and the heat rejected in the exhaust is

$$Q_2 = C_p (T_d - T_a)$$

Hence

$$E = \frac{C_v (T_c - T_b) - C_p (T_d - T_a)}{C_v (T_c - T_b)} = 1 - \frac{C_p}{C_v} \times \frac{T_d}{T_c} \times \frac{1 - \frac{T_a}{T_d}}{1 - \frac{T_b}{T_c}} \quad [1]$$

We have

$$\frac{T_d}{T_c} = \left(\frac{P_d}{P_c}\right)^{\frac{k-1}{k}}; \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots [2]$$

Also

$$\frac{V_c}{V_d} = \left(\frac{P_d}{P_c}\right)^{\frac{1}{k}}, \text{ or } \frac{V_a V_c}{V_a V_d} = \left(\frac{P_d}{P_c}\right)^{\frac{1}{k}}$$

Hence

$$\frac{V_a}{V_d} = \frac{V_a}{V_c}\left(\frac{P_d}{P_c}\right)^{\frac{1}{k}}; \quad \text{but as } \frac{V_a}{V_d} = \frac{T_a}{T_d}$$

therefore

$$\frac{T_a}{T_d} = \frac{V_a}{V_c}\left(\frac{P_d}{P_c}\right)^{\frac{1}{k}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots [3]$$

and

$$\left(\frac{T_a}{T_d}\right)^k = \left(\frac{V_a}{V_c}\right)^k \frac{P_d}{P_c}$$

We have further

$$T_b = \left(\frac{V_a}{V_c}\right)^{k-1} T_a$$

and

$$T_c = \left(\frac{V_d}{V_c}\right)^{k-1} T_d; \; V_c \text{ being } = V_b$$

Thence, by division

$$\frac{T_b}{T_c} = \left(\frac{V_a}{V_d}\right)^{k-1}\frac{T_a}{T_d}, \text{ or } \frac{T_b}{T_c} = \left(\frac{V_a}{V_d}\right)^{k}; \frac{T_a}{T_d} \text{ being } = \frac{V_a}{V_d}$$

and

$$\frac{T_b}{T_c} = \left(\frac{V_a}{V_c}\right)^{k}\frac{P_d}{P_c} \quad \ldots\ldots\ldots\ldots\ldots\ldots [4]$$

Substituting [2], [3] and [4] in [1] we get

$$E = 1 - \frac{C_p}{C_v}\left(\frac{P_d}{P_c}\right)^{\frac{k-1}{k}} \times \frac{1 - r\left(\frac{P_d}{P_c}\right)^{\frac{1}{k}}}{1 - r^k\frac{P_d}{P_c}}$$

when the compression ratio $\frac{V_a}{V_c} = r$.

The above is the same thermal efficiency as that of the Atkinson cycle.

The thermal efficiency of the common Otto cycle when the heat is rejected according to the constant-volume line OA (Fig. 16) is

$$E_o = 1 - \frac{1}{r^{k-1}}$$

To make a comparison between the efficiencies E and E_o possible it will be necessary to assume a certain initial pressure from which the sub-adiabatic expansion starts. We may assume: $P_c = 450$ lb. per sq. in. and $P_d = 15$ lb. per sq. in., from which $\frac{P_d}{P_c} = \frac{1}{30}$; the expansion ratio, in both cases the same, $r = 6$; $k = 1.4$; $\frac{k-1}{k} = 0.286$; and $\frac{1}{k} = 0.714$. For the sub-adiabatic regenerative cycle we get

$$E = 1 - 1.4\left(\frac{1}{30}\right)^{0.286} \times \frac{1 - \left(\frac{1}{30}\right)^{0.714} \times 6}{1 - \frac{1}{30} \times 6^{1.4}} = 0.58$$

The efficiency of the Otto cycle becomes for $r = 6$

$$E_o = 1 - \frac{1}{6^{0.4}} = 0.51$$

Assuming, thus, a regenerator efficiency of 100 per cent, then E will be approximately 14 per cent higher than the efficiency of the Otto cycle.

By cooling the expanding charge to a point M below the constant pressure line and rejecting heat along the constant-temperature line MA, a somewhat greater efficiency could be obtained. This would require the regenerator to be cooled by the incoming charge

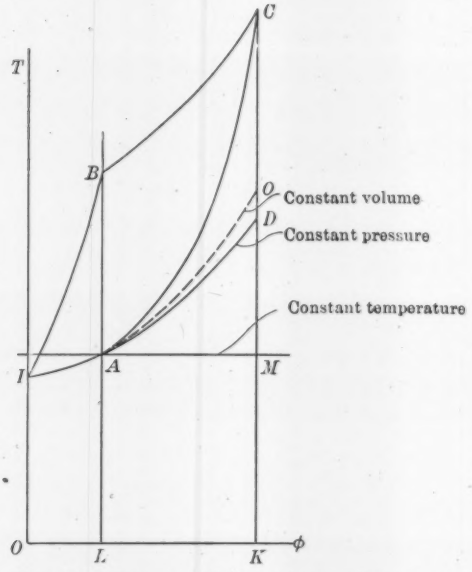


FIG. 16 ENTROPY-TEMPERATURE DIAGRAM

to the low point M and is probably not contemplated in the present cycle.

The Otto cycle is in the entropy-temperature diagram represented by the area $ABCO$, and it will be evident that the temperature range for the two cycles is nearly the same. The required displacement volume is also the same for both and, consequently, practically the same cooling surface will be involved in both cases, excepting that the sub-adiabatic cycle, requiring two cylinders, would include one additional cylinder head.

As the sub-adiabatic regenerative cycle requires a regenerator, an

apparatus whose efficiency cannot, practically, be equal to the unit, it may be proper to debit its thermal efficiency with the loss sustained in the regenerator. The ratio of the heat regenerated to the heat supplied is

$$\frac{\text{Area } CODAC}{\text{Area } CDXAB} = R$$

$$R = \frac{\frac{P_c V_c}{k-1}\left[1-\left(\frac{P_d}{P_c}\right)^{\frac{k-1}{k}}\right] - \frac{P_c V_c}{n-1}\left[1-\left(\frac{V_c}{V_a}\right)^{n-1}\right] - (V_d - V_a)P_d}{\frac{P_c V_c}{k-1} - \frac{P_b V_c}{k-1}}$$

Dividing by

$$\frac{P_c V_c}{k-1}$$

and substituting

$$\frac{V_d}{V_c} = \left(\frac{P_c}{P_d}\right)^{\frac{1}{k}}$$

and

$$\frac{P_b}{P_c} = \left(\frac{V_a}{V_c}\right)^{k} \times \frac{P_d}{P_c}$$

we obtain

$$R = \frac{1-\left(\frac{P_d}{P_c}\right)^{\frac{k-1}{k}} - \frac{k-1}{n-1}\left[1-\left(\frac{V_c}{V_a}\right)^{n-1}\right] - (k-1)\frac{P_d}{P_c}\left[\left(\frac{P_c}{P_d}\right)^{\frac{1}{k}} - \frac{V_a}{V_c}\right]}{1-\left(\frac{V_a}{V_c}\right)^{k}\frac{P_d}{P_c}}$$

If, as before, $\frac{P_c}{P_d} = \frac{450}{15} = 30$ and $\frac{V_a}{V_c} = r = 6$

then

$$n = \frac{\log \frac{P_c}{P_d}}{\log \frac{V_a}{V_c}} = \frac{\log 30}{\log 6} = 1.9$$

and the percentage heat regenerated becomes

$$R = \frac{1-\left(\frac{1}{30}\right) - \frac{0.4}{0.9}\left[1-\left(\frac{1}{6}\right)^{0.9}\right] - 0.4\,\frac{1}{30}\left(30^{0.714}-6\right)}{1-6^{1.4}\times\frac{1}{30}} = 0.33$$

Hence, 25 per cent of the heat supplied is directly transformed into work and 33 per cent is regenerated. If we now assume a minimum loss in the regenerator of 20 per cent, then the total thermal efficiency of the cycle becomes $E = 0.25 + 0.8 \times 0.33 = 0.514$, which is practically the efficiency of the Otto cycle.

In view of this and of the indirectness of its process, it may appear doubtful that the sub-adiabatic regenerative cycle can be of great practical usefulness, though as a thermal cycle it is probably new and of interest.

R. C. H. Heck. Consider the general case of the Frith scheme, as outlined in Fig. 4, and here represented, in both the pressure-volume

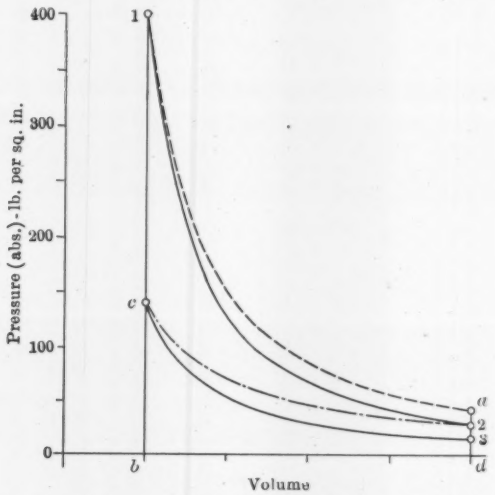


Fig. 17 The Frith Cycle—General Case

and temperature-entropy planes, by Figs. 17 and 18. These are laid out from the governing proportions given in the example in Par. 27, namely, $p_1 = 400$, $p_c = 140$, $p_3 = 14.57$ (there 15), $k = 1.406$, $V_1 = 1$, $V_2 = 5$. Fig. 17 is not related to any chosen quantity of gas, but Fig. 18 is drawn as for one pound of air. Both diagrams are in true proportion.

Outline *c1a3* represents the ideal Otto cycle, with adiabatic expansion. To get the sub-adiabatic expansion, curve *12*, it is assumed that heat can be abstracted by a regenerator in such a controlled and regular fashion as to produce a curve of the form $pv^n = C$, and that this heat can be perfectly restored to the medium during the heat-receiving

operation *c1*. Disregard for the present the isothermal *c2*, which fixes the lower limit of possible regeneration, and also the line *1xy* in Fig. 18 which illustrates a concluding remark.

It will be well to get an expression for the efficiency of this cycle which shall be wholly in terms of the dimensions of the diagram, without involving the awkward regenerative factor F. In some parts paralleling the deduction in the paper, the operation is as follows.

The output of the cycle is

$$U = \frac{P_1V_1}{k-1}\frac{k-1}{n-1}\left[1-\left(\frac{V_1}{V_2}\right)^{n-1}\right]-\frac{P_cV_1}{k-1}\left[1-\left(\frac{V_1}{V_2}\right)^{k-1}\right] \quad \ldots[1]$$

The total heat taken up by the charge during the constant-volume heating *c1*, area *c1db* in Fig. 18, is

$$H = \frac{P_1V_1}{k-1}-\frac{P_cV_1}{k-1} \quad \ldots\ldots\ldots\ldots\ldots\ldots[2]$$

Of this the regenerator supplies the amount *21de*, which it has abstracted from the preceding cycle, leaving to the source the requirement of supplying *23be* plus *c123;* that is, the new heat to be added equals the heat rejected during operation *23* plus the net output of work. For the heat rejected we have

$$\begin{aligned} R &= \frac{P_2V_2}{k-1}-\frac{P_3V_3}{k-1} \\ &= \frac{P_1V_1}{k-1}\left(\frac{V_1}{V_2}\right)^{n-1}-\frac{P_cV_1}{k-1}\left(\frac{V_1}{V_2}\right)^{k-1} \quad \ldots\ldots\ldots[3] \end{aligned}$$

The heat supplied is, therefore,

$$Q = R+U = \frac{P_1V_1}{k-1}\frac{k-1}{n-1}\left[1-\left(1-\frac{n-1}{k-1}\right)\left(\frac{V_1}{V_2}\right)^{n-1}\right]-\frac{P_cV_1}{k-1} \quad \ldots[4]$$

Dividing U by Q to get efficiency E, then dividing through by $\frac{P_1V_1}{k-1}$, we have

$$E = \frac{\frac{k-1}{n-1}\left[1-\left(\frac{V_2}{V_1}\right)^{n-1}\right]-\frac{P_c}{P_1}\left[1-\left(\frac{V_1}{V_2}\right)^{k-1}\right]}{\frac{k-1}{n-1}\left[1-\left(1-\frac{n-1}{k-1}\right)\left(\frac{V_1}{V_2}\right)^{n-1}\right]-\frac{P_c}{P_1}} \quad \ldots\ldots[5]$$

This expression may look complicated, but it is better and clearer than equation [5] in Par. 26.

The fallacy in the paper, which leads to unit efficiency, is involved in the assumption that regenerative action can be carried to the lower limit of temperature, at point *3* in Fig. 17. Heat may be abstracted,

perhaps readily enough, but it cannot possibly be returned to the medium if stored at a temperature lower than t_c, at which heat reception begins. In other words, if any part of the regenerator is cooled below t_c, it must act as a receiver, not as a source of heat, whether during the latter part of operation *3c* (destroying adiabatic compression) or during *c1*. Here the second law of thermodynamics shows its remorseless sway.

As already intimated, the isothermal *c2* fixes at *2* the lower limit of terminal pressure for true regeneration and determines the condition of maximum efficiency for the cycle in its ideal form. To get the value of n in this particular case, we have first the general relation

$$\frac{P_2V_2}{P_1V_1}\left(\frac{V_2}{V_1}\right)^{n-1} = 1 \qquad [6]$$

then the special relation $P_2V_2 = P_cV_1$; therefore,

$$\left(\frac{V_2}{V_1}\right)^{n-1} = \frac{P_1}{P_c}$$

and

$$n - 1 = \frac{\log P_1 - \log P_c}{\log V_1 - \log V_2} \qquad [7]$$

Figs. 17 and 18 are drawn for this limiting condition of maximum efficiency, with the leading dimensions given in the first paragraph of this discussion. The value of n is 1.651 (as against 2.058 for Frith's "maximum" for Fig. 5). The efficiency, by use of equation [5], is

$$E = \frac{\frac{0.406}{0.651}\left(1-0.3507\right) - \frac{140}{400}\left(1 - 0.5203\right)}{\frac{0.406}{0\,651}\left[1 - \left(1 - \frac{0.651}{0.406}\right) \times 0.3507\right] - \frac{140}{400}}$$

$$= \frac{0.4049 - 0.1678}{0.7609 - 0.3500} = \frac{0.2371}{0.4109} = 0.577$$

The use of $n = 2.058$ makes $E = 1$, fulfilling mathematical requirements, but divorced from physical fact.

That all the heat received by the regenerator down to t_c can be returned to the charge after the beginning of operation *c1* is a purely ideal (and unattainable) assumption. Actually, there must be a considerable "head" of temperature, both into and out of the regenerator, or the latter must be cooler (in some part) than the coolest gas from which it is to take heat, and hotter than the coolest gas to

which it is to give heat. The curve *1x*, sketched in on Fig 18, represents what is probably a fair and liberal concession as to the possibilities of the whole scheme. The regeneration of heat *1xyd* would be helpful, but would hardly revolutionize the gas engine.

All this discussion has been concerned with purely ideal conditions. To form even a preliminary judgment as to how well the actual regenerator can perform the function assigned to it, one would have to make a far closer and more definite study of the movements of the charge than is even suggested in the paper. To all reasonable appearance, with the proportions indicated by Figs. 8 and 9, it looks as though the action of the small amount of regenerator surface would be

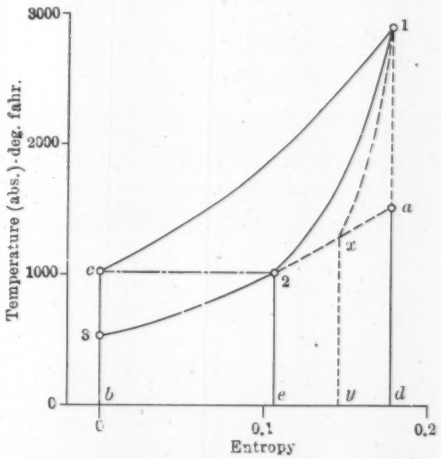


FIG. 18 TEMPERATURE-ENTROPY DIAGRAM FROM FIG. 4

completely overshadowed by that of the very much larger amount of cylinder-wall surface, the latter being backed by a relatively tremendous mass of metal in which there is a steep temperature gradient toward the water-cooled outer surface. Any conclusion based purely on reasoning, whether from theory or from empirical knowledge along analogous lines, must be fully confirmed by actual test before it can be accepted as established.

W. T. MAGRUDER asked Professor Frith if this engine had ever been built. Upon receiving a negative reply, he said that experience led him to think that it would not give the diagrams assumed. He understood that the assumption was made that the heat is all generated along the ignition line, whereas such had not been the case

in gas engines as he had experimented with them. When the temperature-volume diagram is taken, as obtained with a Le Chatelier pyrometer, it will probably be found that the temperature at the middle of the stroke is higher than at the beginning, and possibly still higher at the point of release. Temperatures as high as 2400 deg. fahr. have been experimentally obtained at the end of the expansion. This would make the expansion curve not an adiabatic, but one more nearly isothermal, and possibly one of increasing temperature. He had come to the same conclusion from the use of the combustion sight-hole indicator,[1] consisting of a plate-glass window in the end of the cylinder of the gas engine. Looking through it, one can see the ignition take place and the gases continue to burn in each cycle. For these reasons he could not accept the assumption so common in text-books, namely, that all heat is generated instantaneously, and that the expansion is adiabatic. Such assumptions may answer for the ideal case, but are not in accordance with practice as he had seen it.

CHAS. WHITING BAKER. The author says that the cylinders are connected by a free passage through a regenerator, and he also says there is no clearance in the cylinder. Apparently, then, the volume of the regenerator would have the same effect as an equal volume of cylinder clearance. The drawings (Figs. 8 and 9), show a very small regenerator and a good-sized cylinder. Regenerators, as the author has remarked, are very little known at the present day; but a good many years ago I witnessed one of the old hot-air engines working, which was equipped with a regenerator. Many inventors thirty or forty years ago worked on the design of hot-air engines, of which a regenerator was one of the integral parts. They endeavored to make these regenerators as small as possible, but at best the volume of the regenerator was necessarily several times that of the cylinder. They used to make the regenerators of wire gauze, so as to get the largest regenerative effect in the smallest space; but even then the regenerator was a bulky thing in comparison with the cylinder. In actual work, although the thermal efficiency of the hot-air engine was beyond anything that the steam engine attains, the engine was a commercial failure because the regenerator was extremely short lived.

THE AUTHOR. If the limitations (Par. 24) and the explanation (Par. 25) had been considered, much of this discussion would have been

[1] Engineering News, May 15, 1902, p. 385.

avoided and I might not have been called upon to defend a position I do not occupy. I do not consider that the essential point in this theory has been even mentioned in the discussion. There is an apparent flow of heat in the diagram from a lower to a higher level. If it were so it would be fatal, but it is not true. There is a law that water cannot flow up hill, but no one would quote it against the operation of the hydraulic ram which seems to violate it, because the intervening mechanism is too well known. But suppose it were not so apparent; can not one see how it would be used? The point involved in the present discussion is analogous to this example.

There is apparently a flow of heat from the lower to the higher level and no intervening mechanism or condition can be used in the mathematical demonstration or tolerated in an ideal card. It is not apparent, but it is there and is discussed in Par. 25. All the discussion turns on this point, so we will take Professor Heck's discussion as typical. He calls attention to the necessity of the lower temperature of the regenerator being above the higher temperature of compression. This is admitted in Par. 24. He then deduces the lower temperature of the cycle *from the card* and uses this temperature to show that regenerative action is impossible. Regenerators, however, are governed by the *actual temperatures* with which they are in contact, and I will show that the cycle temperatures *from the card* are not the temperatures at the regenerator surfaces and that using them for such a purpose leads to absurd results. Hence, as the cycle temperature taken *from the card* is the basis of this argument, and in fact of all the arguments, all deductions thereafter and the results obtained from them are also absurd.

That further misunderstanding may be avoided, I refer to Fig. 19, in which let $ABCD$ represent a vessel containing a pound of air. In a partition dividing it there is a hole (h) so that both ends are in free communication. At one end a steam pipe passes through the chamber with a valve as shown. A gage on the vessel gives the pressure of the air. The steam is at 850 deg. abs., the air in one end of the vessel is at 600 deg. abs. and at the pipe end it is 1000 deg. abs. Let the pressure be 40 lb., the volume 50 per cent and the other conditions such that from $\frac{PV}{T} = C$, $T = 800$ deg. This is the temperature of the air in the system calculated from pressure and volume. It is a *card temperature*, the average temperature of the air. But it is not the *actual temperature* at either end of the vessel. Now the second law of ther-

modynamics, as used in this discussion, states that as heat cannot flow from a lower to a higher level, if the valve were opened the 850 deg. steam would give up heat to the air which has a *card temperature* of 800 deg. But since it is really in an atmosphere of 1000 deg., such a statement is absurd, for it is evident that the reverse is true and that the steam would extract heat from the system, while apparently by *card temperatures* heat would flow from the lower level of 800 deg. to the higher level of 850 deg. This is due to the fact that there are two different temperatures actually existing in the vessel. The wider this difference of actual temperatures the greater the absurdity of using *card temperatures* as the basis of the calculation.

Of course the problem would not be changed if a regenerator replaced the steam pipe in contact with the hotter end of the system. As Professor Heck admitted that the deductions in the paper were mathematically correct and as the above illustration demonstrates

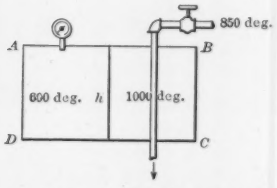


FIG. 19 VESSEL CONTAINING ONE LB. OF AIR

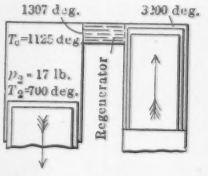


FIG. 20 ACTUAL TEMPERATURES OF FRITH CYCLE

that the flow of heat from a lower to a higher level (*card temperatures*) is not a physical impossibility if a difference of temperatures in the system be wide enough, to that extent he upholds my contention.

To clear up the point raised by Professor Magruder I made a calculation similar to that in Par. 21, in which heat, such as might be supplied by after burning, is added. It offsets in part the heat extracted by the regenerator and increases the heat added by combustion. Incidentally it may keep the temperature in the small cylinder constant, replacing heat abstracted in that cylinder by the work during expansion. This calculation also gives 100 per cent efficiency, but calls for a higher maximum efficiency of regeneration, 85 per cent for the case in Par. 27 (see Fig. 20). Where $T_1 = 3200$ deg. and T_c of compression = 1125 deg., it figures out that the temperature in the small cylinder is always 3200 deg. and is the *actual* temperature in contact with the regenerator. The lower temperature of the regenerator being 1307 deg. *actual*, all controlling temperatures are above the

1125 deg. of compression and the regenerative action may continue to the end of the card, where the pressure for the whole system figures about 17 lb. and the *card temperature* of the cycle is only 700 deg. This regenerative action at *actual temperatures* is possible where the *card temperatures* make it look like a heresy. The efficiency in this case, figured from a calculation like that in Par. 32, is 98 per cent, very close to unity but higher than I would have expected at this limit of action.

I regret exceedingly that the discussion was confined to this 100 per cent efficiency. After all it is only mathematical and the ideal conditions involved are totally unattainable, while for the actual conditions of practice this action of a wide difference of actual temperatures can be maintained, even if it be questionable whether it holds good to the mathematical limit. It does give an apparent upward flow of heat and as the heat is actually transferred at low *card temperatures* it has the same effect as the thermal impossibility, though it is only a trick of construction, the intervening mechanism, analagous to that which is well known and effective in hydraulic rams.

Mr. Baker's remarks in reference to regenerators are, I believe, strictly true, but the inference is not correct. By referring to Fig. 6 it will be seen that the 90 per cent efficiency of the old regenerators gives a length seven times as long as the 50 per cent regenerators proposed, and as the gases will also be transferred under high pressure as against the atmospheric pressures used in the past, the port areas will be smaller by about 1 to 8. Hence the bulk may be $7 \times 8 = 56$ times smaller for this system.

Referring to Par. 37*c*, it will be found that at ignition, when destructive combustion was predicted by Professor Reeves to upset regenerative action, there is nothing but air, that is no flame in the regenerator. Hence the basis of this argument seems to be, in part, imaginary and is certainly exaggerated. I may add that an expression that agrees with actual tests is opposed to the conclusions of Professor Reeves.

It appears to me that the whole subject of thermodynamics is founded on the necessary assumption of an even temperature at any given point of a cycle, that its laws are subservient to this assumption, and in a case like this, where there is purposely a wide departure from the assumption, that possibly the broad limiting deductions may not apply. It is for this reason that my mathematical discussions are expressed in intrinsic heat, not temperatures, and that a physical relation which we can reasonably estimate was used

to check the results. As Professor Reeves points out, thermodynamics is founded on the Carnot cycle and for that very reason with the intolerance of pure mathematics it may not recognize any ultimate solution or cycle differing from this basis. It is believed that to this departure from the underlying assumption and to the use of a cycle that has no isothermal loss we may ascribe for ideal conditions the promise of 100 per cent efficiency. The general effect of this relation will give us a large increase of economy with practical conditions.

Referring to Professor Reeve's temperature-entropy diagrams, it is evident that in the Carnot cycle the function of the isothermal lines is to increase and decrease the entropy and that it is the heat withdrawn by the lower isothermal that prevents the cycle from approaching unity. As Professor Reeves aptly states, in the older regenerative cycles regeneration replaces the adiabatics, leaving the lower isother-

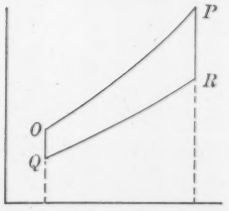


FIG. 21 CYCLE OF ADIABATIC AND CONSTANT-VOLUME LINES

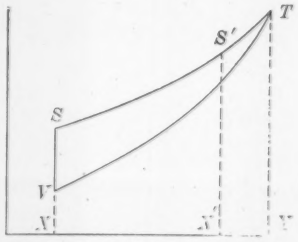


FIG. 22 CYCLE OF FIG. 21 MODIFIED

mal to represent as before a positive loss. If we attempt to replace by regeneration the isothermal instead of the adiabatics we would, if it be practicable, cut out the very line that prevents perfection. Imagine a diagram like Fig. 21, with adiabatics and lines representing the addition of heat at constant volume, regeneration taking place after adiabatic cooling. This cycle seems to be impossible, because the card temperatures during *QR* are lower than those of *OP*. But if we combine the adiabatic *PR* and the regenerative withdrawal of entropy *QR* into one line *TV*, Fig. 22, its average card temperature is apparently lower than *ST*, but not its actual temperatures of heat transfer, all of which figure to be higher than *S* because the adiabatic cooling takes place after the regeneration, though it cannot be shown directly in this form of diagram. But, as I have tried to demonstrate, by the use of a wide difference of actual temperatures, regeneration from *TV* to *ST* is possible, then the area *VTYX* may

equal $XSS'X'$ (heat regenerated) and $X'S'TY$ (heat of combustion) may equal the work done, STV. Hence the efficiency may be 100 per cent for ideal unattainable conditions. A complete temperature-entropy diagram at maximum efficiency for the example in Par. 27 proves every item of our contention, but, with its necessary explanation, it is too long to be here considered.

MODERN SHOE MANUFACTURE

By M. B. Kaven and J. B. Hadaway, Published in The Journal for December 1910

ABSTRACT OF PAPER

This paper treats of the ancient methods of covering the feet, the old-time shoe shop in which each workman was taught to make the entire shoe; the making of the hand-sewed shoe; the advent of the sole-sewing machines, the direct means of revolutionizing the shoe industry; and subsequent inventions substituted for hand work which finally led to the building of the modern shoe factory.

A description is given of such a factory provided with all the modern improvements for the health, comfort and safety of the employees, equipped with the latest type of shoe machinery; and of the principal operations in the making of the shoe, from the cutting of the leather until it is ready for the shipper, with some account of each machine used in these operations. A thorough description is also given of the Goodyear welt sewing machine from which the welt shoe derives its name.

APPENDIX No. 1

DATA FOR FOUR-STORY GOODYEAR SHOE FACTORY

Factory space	300 ft. long by 50 ft. wide. Four floors
Floor space	60,000 sq. ft.
Capacity of factory	3600 pairs men's Goodyear shoes per day Approximate space per pair 16 sq. ft.
Machines in factory	Driven throughout by 1½ h.p.–15 h.p. three-phase 60-cycle motors—550 volts Power to be supplied by a local electric light company

FACTORY PLAN

Fourth floor	Cutting room and stitching room
Third floor	Making room
Second floor	Finishing room, treeing and dressing room, packing and shipping room and general offices
First floor	Sole leather and stock fitting room

Plans are shown in Figs. 7, 8, 9 and 10.

POWER REQUIRED TO DRIVE MACHINES

	H.p. Motors	Total H.p.
Fourth floor	1–1½, 1–10	26.5
Third floor	1–15, 1–10, 2–7½, 2–5	50.0
Second floor	1–10, 2–3	16.0
First floor	1–10, 1–5, 1–3	18.0
Total h.p. for machines		110.5
Estimated power for 2 exhausters		30.0
Estimated power for elevator		10.0
Total h.p. required		150.0

APPROXIMATE LIST OF EMPLOYEES REQUIRED BY THE FACTORY

Cutting room, mostly men	82
Stitching room, mostly women	160
Making room, mostly men	155
Finishing room, mostly men	40
Treeing and packing room, men, boys and girls	47
Sole leather room, mostly men	54
Total	538

NUMBER, KIND AND CAPACITY OF MACHINES USED

Cutting Room—Fourth Floor

Approximately 82 employees are required

No.	Machine	Capacity per machine doz. pairs per day
18	Clicking machines (all parts of upper)	16
	(tops)	38
12	Skiving machines	26
2	Perforating machines	30
2	Tip punching machines	200
4	Upper stamping machines	75
41	Hand cutters (outsides)	6
	(tops)	15

Stitching room—Fourth Floor

One hundred and sixty-four stitching tables for machines and work benches with ten 1½-h.p. motors for drive. Approximately 160 employees are required in this room. Number of machines and operators could be added to as per quality of work exacted.

No.	Machine	Capacity per machine doz. pairs per day
3	Closers (vamps)	110
3	Box toe stitchers	110
5	Tongue stitchers	60
5	Closers (tops)	75
4	Tip stitchers (4 needle)	60
8	Stayers (2 needle)	30
4	Stayers (button fronts)	73
16	Lining stitchers (closers)	25
2	Zigzag stitchers	110
3	Back stayers	60
4	Top facers (back stayers)	80
4	Plain stitchers (labels)	75
4	Eyelet row stitchers	75
15	Under trimmers	20
5	Back stayers (outside)	40
4	Buttonhole machines (24 holes per pair)	5000 holes
2	Buttonhole finishing machines	...
2	Hook setters	165
2	Eyeletting machines	175
3	Barrers (toe linings)	85
25	Vampers (2 needle cylinder)	12
5	Vampers (1 needle cylinder)	7
2	Boston folders	150
3	Barring-up machines	125
2	Button fasteners	100
5	Power cementers	...

Making Room—Third Floor

No.	Machine		Capacity per machine doz. pairs per day
8	Pulling-over machines	Four lasting rinks	40
8	Assembling machines		40
8	Hand method lasters (side lasting)		40
16	No. 5 lasters (toe and heel lasting)		20
1	Tack pulling machine		300
2	Tack pullers and resetters		150
8	Welters		40
1	Power welt groover and beveler		...
1	Inseam trimmer		...
2	Shank welt skivers		150
2	Welt beaters and slashers		150
1	Channel cementer		300
3	Twin sole layers		100
3	Loose nailers		150
6	Universal rounders and channelers		50
2	Channel openers		150
16	Outsole lockstitch machines		20
1	Channel cementer		300
2	Channel layers		150
2	Stitch separators		100
2	Welt indentors and burnishers		150
2	Heel seat rough rounders		150
3	Automatic sole levelers		100
4	Heelers		75
3	Sluggers		100
3	Heel trimmers		100
2	Heel breasters		150
3	Heel scourers		125
15	Edge trimmers		20
7	Twin edge setters		45
2	Welt indentors and burnishers		150
1	Toe tip scourer		...

Finishing Room—Second Floor

Approximately 87 employees are required

No.	Machine	Capacity per machine doz. pairs per day
3	Heel breast scourers	125
5	Heel scourers	75
6	Buffing machines	50
3	Double head pneumatic buffing machines	100
3	72-in. finishing shafts (staining)	100
5	Heel finishers	65
4	72-in. finishing shafts (faking)	100

FINISHING ROOM—SECOND FLOOR (Con.)

No.	Machine	Capacity per Machine doz. pairs per day
1	Loose nailing machine (reinforcing)	300
2	Power stampers	150
1	72-in. finishing shaft (cleaning)	...

TREEING AND PACKING

16	Twin treeing machines	20
1	Vamp creasing machine (f. p.)	300
1	Power marking machine (box marker)	300

SOLE LEATHER ROOM—FIRST FLOOR

No.	Machine	Capacity per machine doz. pairs per day
3	9-ft. sole cutting machines (outsoles)	110
6	4-ft. sole cutting machines (innersoles and top lifts)	125
1	Evening and grading machine	400
1	30-in. rolling machine	350
2	7½-in. splitting machines	150
2	Sole rounding machines	150
2	Feather edge and shank reducers	150
2	Tap skiving and rand splitting machines	200
1	Twin sole molding machine	350
2	Tap and sole rounding machines	150
1	Heel compressing machine	350
6	Power heel building machines	50

GEM INNERSOLES

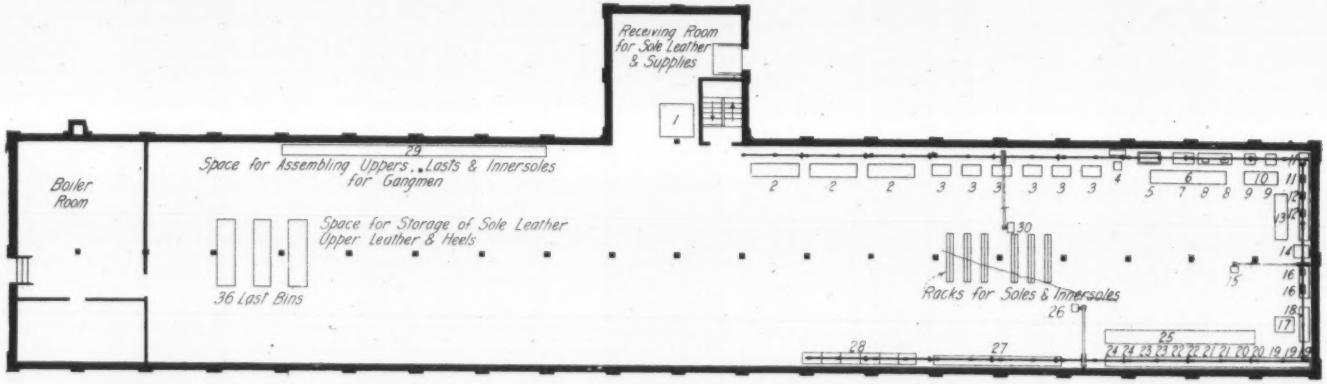
3	Universal channeling machines	125
2	Lip-turning machines	150
2	Rotary cementing machines	150
2	Insole channeling machines	150
2	Insole stitchers	...
2	Insole reinforcers	...

To this number should be added the office force, which would vary from 10, if the product is sold to the jobbing trade, to 30, if to the retail trade.

This factory is planned for a shipment each day, allowing for an occasional delay, but does not provide for an indefinite storage of the manufactured product.

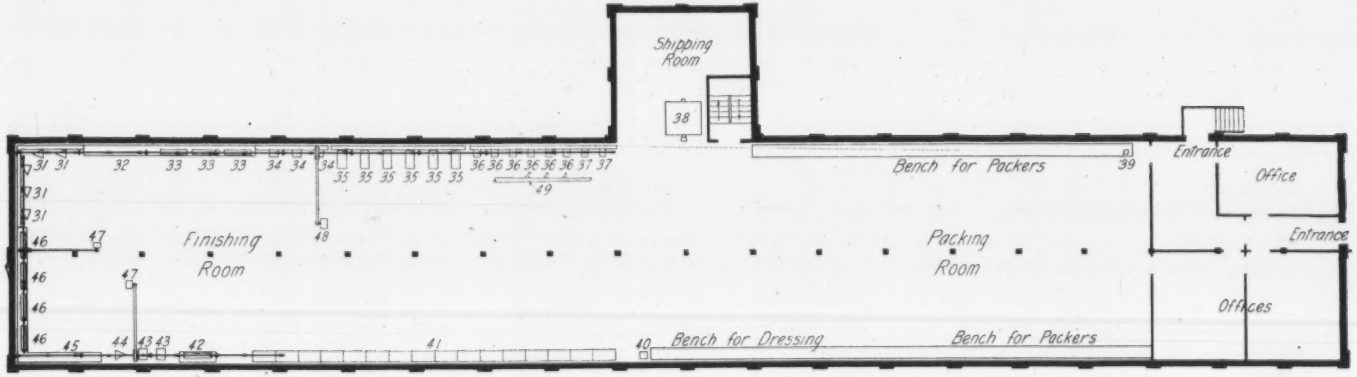
The floor plans (Figs. 7, 8, 9 and 10) represent a four-story factory building each with 15-ft. bays and 2 windows to a bay. The window area should be as large as possible.

The plans show the machines used in their proper order. The outline of the base of the machine is shown, with the necessary benches as required by different machines. The necessary shafting for driving the machines, with the proper size of motor for each drive is also shown. The position of the operator is also shown.


Receiving Room for Sole Leather & Supplies
Boiler Room
Space for Assembling Uppers, Lasts & Innersoles for Gangmen
Space for Storage of Sole Leather Upper Leather & Heels
36 Last Bins
Racks for Soles & Innersoles

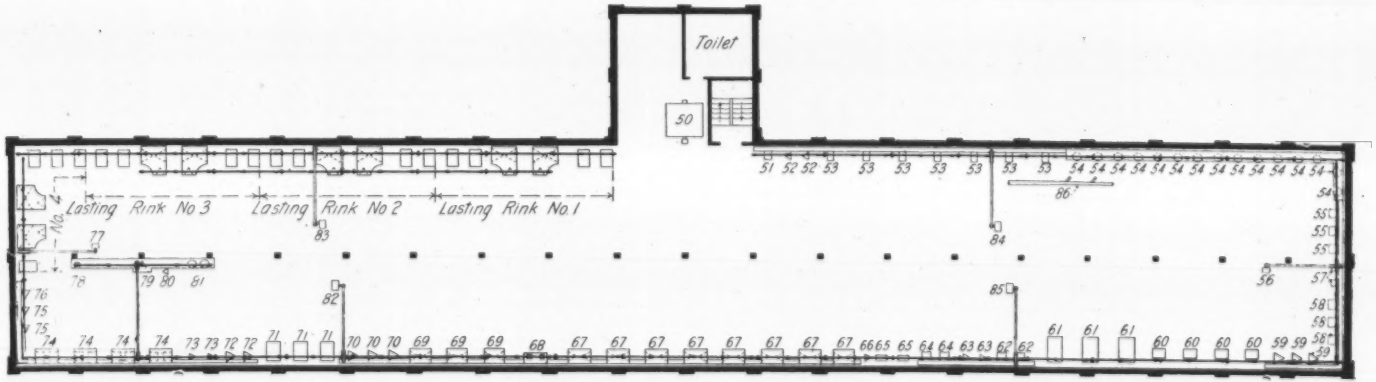
1 Elevator, 8 ft. × 8 ft.
2 Three sole cutters (outsoles and innersoles), 9 ft.
3 Six sole cutters (tops and lifts), 4 ft.
4 Evener and grader
5 Wetting-up tank
6 Work table
7 Rolling machine, 30 in.
8 Two splitting machines, 7½ in.
9 Two sole rounders
10 Rack for patterns
11 Two feather edge and shank reducing machines
12 Two tap skiver or rand splitting machines
13 Work table, 3 ft. × 10 ft.
14 Twin sole molder.
15 5-h.p. motor, 1730 r.p.m.
16 Two tap and sole rounders
17 Heel compressor
18 Heel sorter
19 Three universal channelers
20 Two lip turners
21 Two rotary cementers
22 Two insole channelers
23 Two insole stitchers
24 Two insole reinforcers
25 Stock table, 3 ft. × 35 ft.
26 3-h.p. motor, 1730 r.p.m.
27 Sorting bench
28 Six heel-building machines
29 Bench for assembling lasts, innersoles and uppers for gang men

FIG. 7 FOUR-STORY GOODYEAR SHOE FACTORY
FIRST FLOOR—SOLE LEATHER ROOM



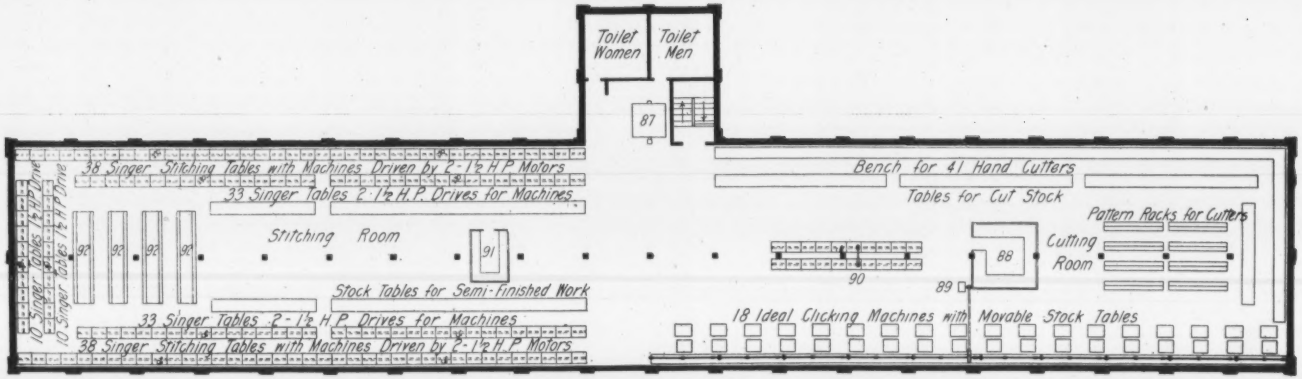
31 Five heel finishers
32 Bench for three blockers
33 Three finishing shafts (staining), 72 in.
34 Three double-head pneumatic buffers
35 Six buffing machines
36 Six heel scourers
37 Three heel breast scourers
38 Elevator, 8 ft. × 8 ft.
39 Power marking machine
40 Vamp creasing machine (f.p.)
41 Sixteen twin shoe treeing machines
42 Finishing shaft (cleaning), 72 in.
43 Two power stampers
44 Loose nailer for reinforcing
45 Bench for three last pullers
46 Four finishing shafts (faking), 72 in.
47 Two 3-h.p. motors, 1730 r.p.m.
48 10-h.p. motor, 1740 r.p.m.
49 Six buffing machines

FIG. 8 FOUR-STORY GOODYEAR SHOE FACTORY
SECOND FLOOR—FINISHING, TREEING AND PACKING ROOM



50 Elevator, 8 ft. × 8 ft.
51 Toe tip scourer
52 Two welt indentors and burnishers
53 Seven twin edge setters
54 Fifteen edge trimmers (machines set in bench)
55 Three heel scourers
56 5-h.p. motor, 1730 r.p.m.
57 Two heel breasters
58 Three heel trimmers
59 Three sluggers
60 Four heeling machines
61 Three automatic sole levelers
62 Two heel seat rough rounders
63 Two welt indentors and burnishers
64 Two stitch separators
65 Two channel layers
66 One channel cementer
67 Sixteen outsole lockstitchers (8 on each drive, benched in as shown)
68 Two channel openers
69 Six universal rounders and channelers
70 Three loose nailers
71 Three twin sole layers
72 Two welt beaters and slashers
73 Two shank welt skivers
74 Eight welters (benched in as shown)
75 Two tack pullers and resetters
76 Tack puller
77 5-h.p. motor, 1730 r.p.m.
78 Power welt groover and beveler
79 Inseam trimmer
80 Channel cementer
81 Bottom filling with heaters
82 10-h.p. motor, 1740 r.p.m.
83 7½-h.p. motor, 1740 r.p.m.

FIG. 9 FOUR-STORY GOODYEAR SHOE FACTORY
THIRD FLOOR—MAKING ROOM



87 Elevator, 8 ft. × 8 ft.; 10-h.p. motor drive
88 Stock room for upper leather
89 10-h.p. motor, 1740 r.p.m.
90 Twenty Singer stitching tables, 1½-h.p., motor drive (12 Amazeen skivers; 2 perforating machines; 2 tip punching machines; 4 upper stamping machines)
91 Supply room for cut stock, etc.
92 Four assembling racks for finished stock

FIG. 10 FOUR-STORY GOODYEAR SHOE FACTORY
FOURTH FLOOR—CUTTING AND STITCHING ROOM

DISCUSSION

E. J. PRINDLE. The art of shoe manufacture should be of interest to mechanical engineers, since the paper states that the making of a Goodyear welted shoe involves the use of 60 different machines. The making of a shoe is a peculiarly difficult and interesting process. The same machines are required to turn out shoes which vary quite widely in sizes and shapes and there is no straight line and nothing to measure from as a base in the view of the ordinary mechanical engineer. Leather is a difficult material to work because it varies considerably in thickness and in stretch, making it difficult to cut out a piece of proper size for a definite part of the shoe. Many of the operations depend upon the success of the preceding ones. This fact, together with the uncertainty of the material and the difficult shape, makes it exceedingly difficult to turn out a good shoe.

The machines involve very interesting mechanical movements and a surprising variety of adjustments to provide for lasts of definite shape of toe, different length and width. There has been an amount of ingenuity displayed in that direction greater than in any other branch of engineering.

Each factory makes its shoes of no standard shape back of the instep, so that there is little uniformity in shoes of different manufacturers. At present, however, there is a strong tendency to make the heel and everything back of the instep of a standard shape in all factories. Another modern tendency is to develop machinery to take the place of the operative now required to hold the shoe up to the machine and to turn it around so that the edge is continually presented.

R. H. LONG.[1] This paper describes well the way a welted shoe is made at the present time and has been made in the shoe factories during the past twelve years.

There has been little progress in shoe manufacturing since 1899, and the advancement since that time has been largely in the division of work; the operations being so divided that skilled labor is used only on the important parts and unskilled labor to large extent.

[1] Shoe Manufacturer, South Farmington, Mass.

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, 29 WEST 39th Street, New York. All discussion is subject to revision.

There has also been much improvement in patterns and in shapes of lasts. The lack of progress so far as machinery is concerned, is owing to the fact that nearly all the shoe manufacturers of the country are controlled by contracts with the United Shoe Machinery Company that prevent the use of competing machines. At the present time the American shoe has not the pronounced leadership in the world that it had ten years ago.

THE AUTHORS. The criticism made by Mr. Long regarding the United Shoe Machinery Company may be refuted by the fact that the company produced during the past year at least 20 new machines in which there are many patentable features of merit and which will result in a saving to manufacturers. The company spends many hundreds of thousands of dollars annually in perfecting new and improved machinery for making shoes and at the present time an exceptionally large number of experimental orders pertaining to improvements and devices are being worked upon. The company endeavors at all times to give shoe manufacturers the benefit of all improvements in shoe machinery made by it, and great advancement is being made at the present time in the production of such machinery. One new invention alone gives promise of saving shoe manufacturers at least two cents on each pair of shoes made.

THE SHOCKLESS JARRING MACHINE

By Wilfred Lewis, Published in The Journal for May 1910

ABSTRACT OF PAPER

The development of machine molding has been limited in the past to machine of comparatively small capacities, but the author believes that the greatest development and the largest savings are to be anticipated in large work quite beyond the capacities of machines hitherto considered practicable. The paper deals with the key to this development, the shockless jarring machine, a new type of jarring machine in which the shock heretofore transmitted to the ground is absorbed as effective work by the machine itself. This machine saves substantially all of the ramming time, and, in combination with others, saves pattern-drawing and finishing time and opens the way to economies of startling magnitude in the foundry. Other labor-saving appliances may be employed still further to reduce the molding time on any given piece of work.

The principles governing the design of a jarring machine include solidity of construction and freedom from vibration in the jarring table, avoidance of shock on foundation from impact, convenience of control, accessibility to all working parts, and economy of power. Solidity of construction is the most important and economy of power the least important consideration. The jarring process is quick and effective, but seldom economical in the consumption of power. Efficiency depends chiefly upon the weight of anvil used, and to some extent upon the length of stroke, the expansive use of air, the clearance, and the character of the sand. The shockless anvil is more efficient than the same anvil cushioned on a wooden crib, and when equal in weight to the loaded table it is twice as effective.

The shockless jarring machine requires no foundation beyond that necessary to sustain the static load, and for this reason it is well adapted for use on the upper floors of buildings, where many foundries are now being located.

DISCUSSION

E. H. Mumford. This admirably clear exposition of a most ingenious machine contains a theory of the action of jolt-ramming machines and some assumptions as to other machines which are disputable.

The American Society of Mechanical Engineers, 29 West 39th Street, New York. All discussion is subject to revision.

In his broad statement of the minute or less required to jolt-ram a mold, and of the effect of anvil recoil, and that the longer the stroke the greater the efficiency, the author ignores the time, varying with the depth of the mold, required for the density of the sand below gradually to reach the top, and treats the compacting of sand by jolt-ramming machines as occurring uniformly and simultaneously throughout the mass.

I refer to the process and not the result, for, although in the finished mold there is a comparatively slight difference in density at top and bottom, a much greater difference exists during the early stages of the ramming and has to be taken account of in anvil and drop conditions. In October 1909 I called the attention of the Philadelphia Foundrymen's Association to the fact that a zone of proper mold density rises gradually from the approximately horizontal joint and pattern surfaces until it nearly reaches the top. Practically as well as theoretically it never does reach the actual top in the time in which the rest of the mold becomes hard enough; and the extreme upper layer must be hand-rammed unless excess sand is used and struck off. In this case, the unrammed upper layer will be in this excess. Were this not true, the many experiments which have been made in ramming molds by dropping sand in cartridges would have borne fruit.

It is stated in Par. 17 that "the longer the stroke the greater the efficiency." If this were correct then a single long stroke of 30 x 2½ in. = 6 ft. 3 in., should ram a mold better than 30 strokes of 2½ in. each. The fact that such a long and, according to the author, efficient stroke, does not ram a mold except in its lower regions, although the author says it should, shows that he thinks of jolt ramming as affecting all parts of the mold simultaneously although the lower layers may be squeezed a little harder by the superincumbent sand. A fall of many times this height, however, would not compact the upper regions of a relatively deep mold, for the simple reason that the lower regions have not been set by previous blows to a rigidity able to transmit the anvil effect. In other words, only the lowest sand gets the effect of a quick stop or high rate of change in velocity, while the uppermost sand lands so gently on the partly rammed sand below as to confute the hypothesis that ramming proceeds uniformly at all depths.

The author gives in Par. 21, as the reason for this behavior of the sand, that "the greater the change in velocity at the moment of impact the [greater the ramming effect." [Now, in [all the upper regions of the mold, where the sand has considerable depth, the rate

of change in velocity at the instant of impact is practically nothing, nor does it become considerable until the sand below has been brought to a density sufficient to transmit effectively the impact on the anvil to the sand above.

For this reason I have stated that the jolt-ramming of sand is a progressive process in which the first impact rams the sand next the rigid horizontal planes to the maximum density possible for the machine, matchboard and patterns used. The next impact affects the sand immediately above *through the medium of the sand already rammed* and so on to the top of the mold in gradually diminishing density. In other words, the inequality in density of the sand at bottom and top of the mold, practically infinite at the first impact, because then the sand at the top is practically wholly unrammed, diminishes as the zone of hard sand rises toward the top. This has nothing to do with the comparative densities of rammed and unrammed sand, but has to do with rammed densities. Unrammed sand has relatively none. This, I think, must be evident. So far as the effect of jolt-ramming is concerned, unrammed sand is zero in density and sand rammed at all is infinitely dense in comparison.

This analysis is the only one which can follow the law stated by the author and just quoted, in which he uses the expression, "the change of velocity at the instant of impact." I think he will agree that no change in velocity of a body *at the instant* of impact is finitely possible, and that what was intended was "the rate of change of velocity at the instant of impact."

In the abridged history given of machine molding, mention should be made of the stripping plate, without which the art cannot be considered complete. Vibrators, though used on molding machines since 1893 for much machine molding, have never displaced the stripping plate. At the outset also the author assumes that the foundrymen have only "hitherto attempted to ram sand by the jarring process." This is a false assumption, for jolt-ramming of sand has been perfectly done for twenty years and numbers of machines good for 15 tons on the table have been in successful use for several years.

In reference to the designation in Par. 18 of the tables of other machines as " flimsy," other designers seek to avoid the large percentage of unnecessary weight and destructive shock involved in making the table carry the heavy stiffening which it needs only at the moment of impact and their machines receives and supports it on an ample surface at this time.

The author defines jolt-ramming machines as "capable of ramming any mold large or small in a minute or less time." This would lead to a mistaken idea that the size, or rather the depth, of a mold is immaterial in a machine of given capacity. One of our 16-in. machines which rams a 10-in. barred green sand cope with 20 blows in 10 seconds requires a minute and a half to ram an ingot mold core 6 ft. deep with 190 blows.

Reference is made in Par. 10 to pattern-drawing machines. Such machines as Mr. Lewis advocates require that the patterns should be attached to the machine, which is not the case with the simple jolt-ramming machines. Pattern-drawing machines as adjuncts to jolt-ramming machines do not save time, for they exact separate transportation of flasks and sand between the machine and molding floor, otherwise unnecessary. A recent description of one of these combination machines, costing over $2000, gave its output with four men as 50 truck wheel centers in ten hours. A plain jolt machine costing $900 has made 40 wheel centers in the same time with three men for the past four years with no pattern-drawing machine at all.

Money should not be spent for heavy stationary power machines to roll molds and draw patterns when a crane will pick up any mold by flask trunnions, on which it has practically rolled itself by the time it is set down where it is wanted. All then needed is a pattern guide, and a simple modification of the time-honored "steady-pin" or flask pin gives that in ninety-nine cases out of a hundred.

In Par. 12 the author gives all the work except the crane work on 16 molds 45 in. x 60 in. x 30 in. (such a mold might weigh 5500 lb.) as done in eight hours, and thus overlooks the great question of lifting and carrying in connection with the jolt-ramming of large molds. There are 64 lifts and carries to be made on this job. So it can be judged in how far from the eight hours named it is possible to make and finish 16 molds of this size with the help necessary to perform only the operations described in the schedule.

I think the author exaggerates the damage by shock or jarring of the foundry floor by jolt-ramming machines. Of course a great deal depends upon the nature of the work near the machine. In congested localities in cities, where heavy machinery such as steam hammers is objectionable to the neighborhood, a machine such as the author's finds a unique fitness. Heavy hanging green sand cores should not be placed near jolt-ramming operations, especially on swampy ground, but abundant testimony is to be had that the simpler form of machine is no such Aetna-shaking Pluto as claimed.

We have put in service a 32-in. plain machine, which with 100 lb. air service is ramming half molds weighing 40,000 lb., and the question of shock in the foundry is ridiculed by the management. Were anvils of other designers' machines as badly proportioned as reported there might be some excuse for the strictures made; but they are not.

It is assumed in the paper that the "weight of the anvil is generally limited to the weight of the loaded table," and the author develops from this assumption that the ordinary jolt-ramming machine has only 25 per cent efficiency as compared with one having an anvil of infinite weight, or bedded on rock. Fortunately for the art, anvils in use are quite commonly three times and sometimes seven times the weight of the maximum loaded table, which means that anvils are from six to at least ten times the weight of average loaded tables. Only one builder has followed the bad practice of placing a timber crib on top of the concrete. What this means follows:

Ratio Anvil To Loaded Tables	Efficiency of Machine	Remarks
Anvil equals loaded table	25 per cent	Assumption by author
Anvil twice loaded table	44 per cent	Minimum practice under maximum load
Anvil three times loaded table	55 per cent	Usual practice under maximum load
Anvil six times loaded table	73 per cent	Occasional practice under maximum load
Anvil seven times loaded table	77 per cent	Usual practice under average load
Anvil ten times loaded table	81 per cent	Occasional practice under average load

So it seems that the author claims that current jolt-ramming practice wastes two to three times as much energy as in fact it does.

The shockless jarring machine referred to in Par. 31 as having 50 per cent efficiency as compared with a machine having an infinite anvil, has an anvil of comparatively trivial mass, but doing the work of an anvil of infinite mass by stopping the falling table dead at impact.

This compares well with the 25 per cent derived in the paper for other machines, but does not look so well beside the 55 to 81 per cent with which they should be credited.

Now let me raise the question of mechanism. In the first place it is to be remembered that a machine which is mechanically fit for machine-shop or even smith-shop use may be a failure in the foundry.

Dry sharp sand is omnipresent. It might be thought that in a closed pit under a machine the flying, cutting, erosive dust would not prevail. But the pit is not closed. There is inevitably a fissure around the table through which during its operation, a steady shower of sand falls in a thin sheet to the bottom of the pit, a distance of fully 12 ft. in the machine described, in the presence of a blast surging up and down through the floor openings produced by the pulsations of the table, and a hurricane of dust if the exhaust is open to the pit as shown in the illustrations.

What will be said of the upturned, open, working joint of this subterranean cylinder in the "shockless" machine? And in the bottom of this cup, in water and intruding sand, under a reciprocating mass of 32 tons (57 tons and more, loaded) are 22 springs. Springs like men are temperamental. We all know how some lazy springs in a group will shift their load to abler partners and let their side sag.

The author has provided a "drip cock" to let the water out of the bottom of the spring box and cylinder guiding 65,000 lb., but what will be done with the sand? Is exhaust pressure in this cylinder supposed to keep the sand out? Experience with lubricated or wet plunger fits exposed to sand is that air gets out while sand gets in.

Still another foundry condition militates against the design of this machine. Not one load in a hundred placed by a crane on the table of a jolt-ramming machine is balanced over the plunger. Jolt-ramming plungers of all machines are suffering from eccentric loading.

The centers of gravity of sand molds are rarely in the vertical center lines of the flasks; and it is practically impossible to balance them by the eye on the machine tables. In a machine of such magnitude, the moment due to the jamming and wearing of the plunger may amount to many thousand foot-pounds. The lopping over of plungers in jolt-ramming machines due to unbalanced loading and wear is bad enough with one plunger; with two we would have the wear of one added to that of the other.

The author seems to have overlooked the fact that it is easy to secure balanced loading of these tables by a boss in the center of the table which serves to locate molds centrally. Corresponding wooden sockets on the match boards are, by a simple balancing on rollers, located vertically under the centers of gravity of the molds.

In order that the ramming impact in any jolt-ramming machine may be according to mechanical law, the center of gravity of the

loaded table and the center of gravity of the anvil must be in the same vertical line. It is easily practicable to keep jolt-ramming impacts central, and I believe it vital to any so-called "shockless" machines in which, as in this Tabor machine and as in steam hammers, the heavy deflecting shocks of eccentric impact are delivered to the mechanism instead of to *terra firma*.

Other designers of jolt-ramming machines find an absolutely reliable plunger compression a far more satisfactory agent for controlling table stability than springs of which the author shows 22 in the base and one in the top, while practically all the energy absorbed in this *air* spring is immediately utilized for the next blow.

A. E. OUTERBRIDGE. The chief objection to jarring machines has been ground waves due to shock. Granted that this trouble may now be eliminated, without loss of ramming power and proper flow of sand, by means of the floating anvil, there is apparently almost no limit to the future development of the molding machine. Even today, quite large castings are being made successfully on jarring machines, that a few years ago would have been considered beyond the capacity of any molding machine.

In the foundry of Wm. Sellers & Co., Inc., a jarring machine made by the Tabor Mfg. Co. negotiated flasks 80 in. x 70 in. x 40 in. deep in the drag and 16 in. deep in the cope, containing 120 cu. ft. of sand. The live heads for several large lathes have been made on this machine in this flask, the weight of the sand and the flask being 16,880 lb. and the weight of the casting about 9000 lb. Machine uprights have also been made in flasks 140 in. x 50 in. x 38 in. deep in the drag and 10 in. deep in the cope. This flask contains 129 cu. ft. of sand; the sand and flask together weigh 20,640 lb. These castings being of comparatively thin section, weigh about 4500 lb. each.

Apart from the lower cost of molding these large castings on the jarring machine there is a more uniform weight of duplicate castings and a more uniform distribution of the sand. The absence of "spongy spots" and "hard spots," inseparable from hand ramming, tend to insure good castings.

The chief, if not the only objection, to the operation of this machine in the foundry is the "earthquake," tending to cause sand to drop in contiguous molds in the floor, and in order to overcome this arrangements are now being made to adapt the shockless principle to the jarring machine already installed. When this has been accom-

plished it is believed that green sand molds with large overhanging portions can be safely made in the floor alongside of the shockless jarring machine.

THE AUTHOR. In reply to the discussion which has been given on my paper, I am grateful for the appreciation expressed and for any well-founded criticisms, whether favorable or otherwise, which may lead to further improvement, but I object to unwarrantable assumptions as the basis for conclusions which do not apply to the subject in hand.

I do not propose to argue whether the adjective "flimsy" applies more pointedly to a light thin wafer of cast iron which can be easily sprung or peened out of shape, than to a deep beam securely braced in all directions, because foundrymen generally have ideas of their own and no lack of adjectives to give them force. I deny, however, that my jarring table is loaded down with excessive weight because of its enormous strength and stiffnesss. Metal well distributed is used to good advantage, and here again no argument is needed.

It has been said that I treat the compacting of sand by jolt-ramming machines as occurring uniformly and simultaneously throughout the mass, whereas in the second paragraph of my paper, I say, referring to this method of ramming, "The sand is rammed as it should be, densest at the surface of the pattern and of decreasing density above, thus favoring the escape of gases when the mold is poured." I never had any other idea about it, and never met anyone who pretended to think that jar-ramming formed a crust on top of a mold while the sand beneath was nice and soft. There is nothing in my paper to indicate in any way that my understanding of the process is at all different from the common understanding of it as set forth by my critic. Nor does the acceptance of this understanding affect my contention that the longer the stroke the greater the efficiency. The ramming effect referred to in my paper is the kinetic energy given out by a change in velocity due to impact, and utilized more or less in compacting the sand. I do not contend that the longer the stroke the better the mold nor that one stroke of 75 in. is better than 30 strokes of 2.5 in. I recognize distinctly the limitations in length of stroke imposed by the practical considerations of strength and stiffness in patterns, flasks and the machine itself, and the advantage of repeated blows, but I dispute the possibility of ramming as hard on a short stroke as on a long one, notwithstanding the contention made to the contrary. Further than this,

the fact as I have stated it has been demonstrated by experiment and I am quite prepared to prove that in jar-ramming, the longer the stroke the greater the efficiency. On a shockless jarring machine with variable stroke, I have rammed a deep mold by giving it several hundred blows 1 in. long until the compacting of the sand appeared to have reached its limit. Then by increasing the length of stroke from 1 in. to 4 in., I have seen the very next blow reduce the depth of sand nearly 2 in. and succeeding blows naturally produced less and less movement as the ultimate density of the sand for the greater drop was approached. I am very confident, therefore, that there is an ultimate density for every length of stroke, and when this truth is realized, as it must be by anyone who takes the trouble to investigate, there can be no question as to the truth of my contention that the longer the stroke the greater the efficiency of a jarring machine. Take for instance, the mold above referred to, which has been rammed to its ultimate density by 1-in. strokes. A hundred more strokes of that length would have no perceptible effect, but one stroke of 4 in. would have a very substantial effect. After the ultimate density corresponding to the drop has been reached, all of the power expended is wasted, and nearly all the power used is wasted as this ultimate density is approached. Economy of power clearly points to the use of the longest stroke practicable, while on the other hand, the wear and tear on the machine, flasks and patterns suggest moderation and the adoption of a safe limit within which the stroke can be varied to meet the exigencies of any given case. It is better, I believe, not to begin jarring with a very long stroke, on account of the air confined in the sand, which may cut a channel for itself and blow if the stroke is too long, but after the sand has been well settled, I am very sure the stroke can be lengthened with great economy in power and generally with very good results.

It should also be observed that continued jarring after the mold has reached the ultimate density due to the stroke not only wastes power but spoils the mold, for as soon as the sand ceases to pack it begins to break up. The success of the process, therefore, depends a good deal upon knowing when to stop as well as upon the character of flasks, sand and patterns and the knowledge gained by actual experience in any given case.

The progressive nature of jar-ramming from the bottom up is, I believe, self-evident, but the density of sand when unrammed on the floor or rammed up in different parts of a mold is naturally proportional to its weight per unit of volume under these different con-

plished it is believed that green sand molds with large overhanging portions can be safely made in the floor alongside of the shockless jarring machine.

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I do not propose to argue whether the adjective "flimsy" applies more pointedly to a light thin wafer of cast iron which can be easily sprung or peened out of shape, than to a deep beam securely braced in all directions, because foundrymen generally have ideas of their own and no lack of adjectives to give them force. I deny, however, that my jarring table is loaded down with excessive weight because of its enormous strength and stiffnesss. Metal well distributed is used to good advantage, and here again no argument is needed.

It has been said that I treat the compacting of sand by jolt-ramming machines as occurring uniformly and simultaneously throughout the mass, whereas in the second paragraph of my paper, I say, referring to this method of ramming, "The sand is rammed as it should be, densest at the surface of the pattern and of decreasing density above, thus favoring the escape of gases when the mold is poured." I never had any other idea about it, and never met anyone who pretended to think that jar-ramming formed a crust on top of a mold while the sand beneath was nice and soft. There is nothing in my paper to indicate in any way that my understanding of the process is at all different from the common understanding of it as set forth by my critic. Nor does the acceptance of this understanding affect my contention that the longer the stroke the greater the efficiency. The ramming effect referred to in my paper is the kinetic energy given out by a change in velocity due to impact, and utilized more or less in compacting the sand. I do not contend that the longer the stroke the better the mold nor that one stroke of 75 in. is better than 30 strokes of 2.5 in. I recognize distinctly the limitations in length of stroke imposed by the practical considerations of strength and stiffness in patterns, flasks and the machine itself, and the advantage of repeated blows, but I dispute the possibility of ramming as hard on a short stroke as on a long one, notwithstanding the contention made to the contrary. Further than this,

the fact as I have stated it has been demonstrated by experiment and I am quite prepared to prove that in jar-ramming, the longer the stroke the greater the efficiency. On a shockless jarring machine with variable stroke, I have rammed a deep mold by giving it several hundred blows 1 in. long until the compacting of the sand appeared to have reached its limit. Then by increasing the length of stroke from 1 in. to 4 in., I have seen the very next blow reduce the depth of sand nearly 2 in. and succeeding blows naturally produced less and less movement as the ultimate density of the sand for the greater drop was approached. I am very confident, therefore, that there is an ultimate density for every length of stroke, and when this truth is realized, as it must be by anyone who takes the trouble to investigate, there can be no question as to the truth of my contention that the longer the stroke the greater the efficiency of a jarring machine. Take for instance, the mold above referred to, which has been rammed to its ultimate density by 1-in. strokes. A hundred more strokes of that length would have no perceptible effect, but one stroke of 4 in. would have a very substantial effect. After the ultimate density corresponding to the drop has been reached, all of the power expended is wasted, and nearly all the power used is wasted as this ultimate density is approached. Economy of power clearly points to the use of the longest stroke practicable, while on the other hand, the wear and tear on the machine, flasks and patterns suggest moderation and the adoption of a safe limit within which the stroke can be varied to meet the exigencies of any given case. It is better, I believe, not to begin jarring with a very long stroke, on account of the air confined in the sand, which may cut a channel for itself and blow if the stroke is too long, but after the sand has been well settled, I am very sure the stroke can be lengthened with great economy in power and generally with very good results.

It should also be observed that continued jarring after the mold has reached the ultimate density due to the stroke not only wastes power but spoils the mold, for as soon as the sand ceases to pack it begins to break up. The success of the process, therefore, depends a good deal upon knowing when to stop as well as upon the character of flasks, sand and patterns and the knowledge gained by actual experience in any given case.

The progressive nature of jar-ramming from the bottom up is, I believe, self-evident, but the density of sand when unrammed on the floor or rammed up in different parts of a mold is naturally proportional to its weight per unit of volume under these different con-

ditions, and if unrammed sand had no density it could not have any weight and would be lighter even than air. Zero density has been attributed to the ether which is supposed to fill all space, but never before to sand. If it be true as stated in the Iron Age (July 1909) that the density of sand is increased 25 to 30 per cent by ramming, it can hardly be true as stated now by the same authority that the difference in density of the sand at top and bottom of the mold is practically infinite at the first impact.

As to the change in velocity of the table at the instant of impact, I mean, of course, the change in velocity during that very minute fraction of a second while the pressure of impact exceeds the static load. I do not mean the *rate* of change in velocity at the instant of impact, because that rate does not hold throughout the duration of contact, and it has very little to do with the final result.

I am said to assume at the very outset of my paper that foundrymen have only "hitherto attempted to ram sand by the jarring process," in answer to which I would refer to the third paragraph, which begins "Jarring machines have been in practical use for many years without attracting much attention. The records of the patent office go back to 1869," etc., making further comment on this criticism superfluous. Nor does it refute my estimate of the time needed to ram any mold on a jarring machine to say that some machines require a minute and a half to do what the shockless machine certainly could do in a minute or less time.

As to the damage done by shock in the foundry floor, a good deal of evidence has been presented in discussions of the subject at various meetings, Mr. Outerbridge has confirmed it in his discussion and many others have had the same experience. Where the shock of steam hammers has to be endured, I do not think it would be worth while to put in a shockless jarring machine, but the choice rests with the user, and in addition to the evidence for the need of a shockless jarring machine already adduced, let me quote a paragraph from a letter received from abroad: "We are employing in our foundry a jarring machine with 48 in. x 60 in. table, on which we make molds weighing with sand and flask from 1500 to 2000 Kos. but our neighbors are complaining of the shocks which are transmitted to the ground and are even damaging our molds when we place the cores."

In regard to the weight of anvil being generally limited to that of the loaded table, I would say that this conclusion was reached from a number of observations, and confirmed indirectly by the

same authority who now disputes it. I am glad to be assured, however, that my estimate is too low, because the greater the weight of anvil or the more the money buried under ground by competitors, the better for the shockless machine, whose uprising anvil is always more efficient than an anvil of double its weight mounted on a wooden crib.

I know there is some prejudice against the use of springs, founded chiefly upon ignorance of the duty they should be made to perform. I have seen a great many springs which failed to act as intended and sometimes this has been due to the use of wrought iron or brass instead of high carbon spring steel properly tempered, but when good material is employed, I have seldom known a spring to fail except from bad design, and good steel springs within certain well defined limits, I believe to be as reliable as any other piece of mechanism. The railroads are the largest comsumers of spring steel. They specify the working stresses found to be safe and by keeping well within their limits the uncertainty about the action of steel springs may be dismissed as no greater than that attached to any other element of machine construction.

Of course, it is important to have the load central on any jarring machine and since there is no difficulty about locating it in that position, it is hardly worth while to consider at length the effect of eccentric loads. That a reasonable amount of displacement does not appreciably affect the action of the shockless machine is shown by shifting the sand in a large flask.

It must be apparent to anyone who considers the subject that the table itself causes a greater intensity of pressure on the buffer ring between it and the anvil than any amount of sand piled upon the table, and that this blow is central in a properly constructed machine. This solid blow, delivered by comparatively unyielding parts, is sharp and its effect is short-lived, but it is followed immediately by pressure due to the arrested momentum of the flask and sand, which is much less intense and of much greater duration especially during the early stages of the jarring process. No trouble has arisen from this cause and none is to be feared, especially as there are several expedients which may be easily and effectively applied if thought necessary to absorb these little eccentric effects.

In regard to the effect of sand and dust, I do not pretend to say that these elements are worth much as lubricants for machinery, but I can refer to a table of the type described in my paper which has been in successful operation for more than three years, and I must

emphatically deny that dust can work in where air under pressure is working its way out. In the machine which exhausts through the anvil cylinder, I prefer to leave the drip cock open or simply use an open pipe through which part of the air and all the entrained water is continuously passing while the machine is running. There is, therefore, less danger from sand and dust in the working of the shockless machine than in other types.

In regard to the value of pattern-drawing appliances on molding machines, it is quite true that in some cases this work can be done well enough by a crane if the user of the machine is in no hurry, but if he wants quick and efficient service he will find that the crane must be attached to his machine and have nothing else to do. Otherwise more time may be wasted in waiting for the crane than is saved by power ramming and but little advantage will be found from the use of the molding machine. My object in referring to pattern-drawing appliances attached to jarring machines was to illustrate the great advantage of the combination over the advantage to be derived from each element independently. In other words, it pays to bunch hits in efficiency as well as in base-ball and the figures I have given, whether actually realized or not, illustrate this point.

In regard to the tabulated efficiencies of various weights of anvil it must not be forgotten that shockless anvils can, like plain anvils, be made just as heavy as the customer wants to pay for. It is true for both types of machines that the heavier the anvil the greater the efficiency, but in the shockless machine the same efficiency can be realized with less than half the weight required for a plain machine and when air is expanded into the anvil cylinder the efficiency of the shockless machine is still further augmented.

GAS POWER SECTION

PRELIMINARY REPORT OF LITERATURE COMMITTEE

(IV)

ARTICLES IN PERIODICALS

AEROPLANES AND AIRSHIP ENGINES. *Machinery (English Edition), January 1911.* 4 pp., 13 figs. *bdf.*
Details and description of different types.

BRAKE, CALCULATING H.P. BY PRONY, Charles O. Alexander. *Gas Power, January 1911.* 2 pp.

BRAKING WITH THE ENGINE, Charles Clinton Cowle. *The Gas Engine, December 1910.* 2 pp.
Describes method of using engine as its own brake.

COMPRESSION, LOST, C. R. McGohey. *Gas Power, January 1911.* ¾ p.
Effect of worn bearings on compression.

COOLING GAS ENGINES, G. H. Murdock. *The Gas Engine, November 1910.* 4 pp., 3 figs.
Cooling system as applied to small engines

COSTS, GAS POWER PLANT, R. S. Manning. *Power, December 6, 1910.* 1 p., 2 tables.
Fuel and installation costs of a station consisting of two twin-tandem double-acting horizontal Allis-Chalmers gas engines supplied from Loomis-Pettibone bituminous producers and direct connected to 1000-kw. generators.

ENGINE, A NEW GERMAN GAS. *The Iron Age, January 5, 1911.* 2⅓ pp., 6 figs. *b.*
Details of the double-acting four-cycle engine built by Ehrhardt and Sehmer.

ENGINE PLANT, AN 1800-H.P. GAS, M. S. Smith. *The Gas Engine, November 1910.* 2 pp.
Cleaning of the gas from soft coal producers, and scrubbers used.

ENGINE PRACTICE, MODERN GAS. *The Gas Engine, November 1910.* 3 pp., 3 tables.
Gas consumption, thermal efficiency and notes on operating.

ENGINE, THE HERMAN AERIAL GASOLINE. *The Iron Age, November 3, 1910.* 1 p., 1 fig.

ENGINE, THORNYCRAFT MARINE-OIL. *Engineering (London), October 28, 1910.* 1 p., 3 figs. *bC.*
Exhibited at North-Sea Fisheries, Great Yarmouth.

ENGINE, WILLANS AND ROBINSON'S TWO-STROKE CYCLE ENGINE. *Power, November 1, 1910.* 2 pp., 2 figs.

FLYWHEELS FOR INTERNAL-COMBUSTION ENGINES, PROPORTIONS AND DESIGN, D. O. Barrett. *Machinery, November 1910.* 2 pp., 2 figs.

GOVERNING MECHANISMS FOR GAS ENGINES, MODERN, W. H. Miller. *Power, October 18, 1910.* 4 pp., 10 figs. *bf.*

IGNITION CIRCUITS, EMERGENCY AND ALARM SYSTEMS FOR, W. T. Garlitz. *Power, November 22, 1910.* 1 p., 1 fig.

LIGNITE AS FUEL, PERFORMANCE OF A GAS POWER PLANT USING, A. M. Levin. *Power December 27, 1910.* 3 pp., 1 fig., 6 tables.
Results of tests.

LUBRICATION, J. N. Bagley. *Gas Power, November 1910,* 1½ pp.
Necessity and results of decreasing friction.

OIL ENGINE AT FLORENCE, COLO., EXPERIMENTAL INSTALLATION AND TEST OF DE LA VERGNE. *The Gas Engine, December 1910.* 3 pp., 1 fig., 1 table.
An interesting feature in connection with this test is that while the efficiency of gas engines at the altitude of Florence, Colo., is only 80 per cent, the engine in question is competent to assume an overload of 10 per cent and give an efficiency of 88 per cent net h.p.

OIL MOTORS FOR FISHING BOATS. *Engineering (London), November 4, 1910.* 1 p. *bC.*
Description of marine oil motors exhibited at North Sea Fisheries and Shipping Exhibition at Yarmouth.

OIL WATER GAS PLANT, LOW-CONDE, H. B. MacFarland. *Gas Power, January 1911.* 1 p.

PACKING GAS ENGINE, George Cormack, Jr. *Gas Power, December 1910.* 2 pp.
Experiences from cheapest to best.

PUMPS AND COMPRESSORS, HUMPHREY, Herbert A. Humphrey. *Engineering (London), November 18, 1910.* 4⅓ pp., 20 figs., 5 curves. *bA.*
A very complete paper on this interesting pump.

PRODUCER DESIGN AND OPERATION, GAS. SOME CONSIDERATIONS AFFECTING THEIR SUCCESS, P. Von Zeipel. *The Iron Age, November 17, 1910.* 2 pp., 5 figs. *abdf.*
Notes on operating difficulties, progress in designing and history.

PRODUCER, ELEMENTARY LECTURES ON THE GAS, C. P. Poole. *Power, December 6, 1910.* 1⅓ pp., 3 tables.
Specific heat of gases.

PUMPS FOR CHINGFORD RESERVOIR, GAS. *The Engineer (London), November 11, 1910.* ⅓ p., *bC.*
Short account of the letting of contract for Chingford reservoir to have capacity of 180,000,000 gal. in 24 hours.

POWER, SOME PERTINENT FEATURES RELATING TO GAS, E. D. Dreyfus. *The Electric Journal, January 1911.* 11 pp., 3 figs., 3 tables, 3 curves.
Types of engines and producers and station operating costs.

TRACTOR, ENGLISH OIL, Frank C. Perkins. *Gas Power, November 1910.* 1 p., 1 fig.
Efficiency of the oil tractor on the farm.

TURBINE, THE GAS, F. R. Low. *Power, November 1, 1910.* 1 p.
On Armengaud and Lemale turbine.

GENERAL NOTES

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

The Pittsfield-Schenectady Mid-Year Convention of the American Institute of Electrical Engineers opened on Tuesday afternoon, February 14, at the Mohawk Golf Club, Schenectady, with two technical sessions, occupying the afternoon and evening. E. A. Baldwin, Chairman of the Local Committee, made an address of welcome, and the convention was formally opened by the President of the Institute, Dugald C. Jackson, Mem.Am.Soc.M.E. Technical papers were presented upon High Tension Testing of Insulating Material, by A. B. Hendricks; Hysteresis and Eddy Current Exponents for Silicon Steel, by W. J. Wooldridge; Commercial Problems of Transformer Design, by H. R. Wilson; Design, Construction and Tests of an Artificial Transmission Line, by J. H. Cunningham; Protection of Electrical Transmission Lines, by E. E. F. Creighton; Tests of Grounded Phase Protector on the 44,000-Volt System of the Southern Power Company, by C. I. Burkholder and R. H. Marvin; Tests of Losses on High Tension Lines, by G. Faccioli. On Wednesday, February 15, a special train left Schenectady for Pittsfield at 8.30, making a short stop at Albany. On arrival in Pittsfield, a tour of inspection was made of the General Electric Company's works. A professional session occupied the afternoon, papers being presented upon Mechanical Forces in Magnetic Fields, by C. P. Steinmetz, Mem.Am.Soc.M.E.; Problems in the Operation of Transformers, by F. C. Green; The Regulation of Distributing Transformers, by C. E. Allen; Temperature Gradient in Oil-Immersed Transformers, by James Murray Weed; Dissipation of Heat from Self-Cooled, Oil-Filled Transformer Tanks; by J. J. Frank and H. O. Stephens. A dinner was given in the evening in the Hotel Wendell and the party returned to Schenectady by special train. The concluding session occupied Thursday morning, and included papers on Oil-Break Circuit Breakers, by E. B. Merriam; Proposed Applications of Electric Ship Propulsion, by W. L. R. Emmet, Mem.Am.Soc.M.E.; Voltage Regulation of Generators, by H. A. Laycock; and Briefs on Vector Rotation, by E. J. Berg and W. S. Franklin.

AMERICAN INSTITUTE OF MINING ENGINEERS

At the annual business meeting of the Corporation of the American Institute of Mining Engineers on February 21 at the Institute headquarters in New York, the following officers were elected: President, Charles Kirchhoff, Mem.Am.Soc. M.E.; Secretary, R. W. Raymond; Vice-Presidents, S. B. Christy, W. A. Lathrop and Gardner F. Williams; Councillors, A. E. Carlton, W. J. Olcott and E. L. Young.

On June 6, the institute will hold a meeting in the Pennsylvania anthracite region, where it was organized at the Wilkes-Barre meeting of May 1871. Headquarters will be the Glen Summit Springs Hotel, Luzerne County, Pa., near Wilkes-Barre.

Plans are also in progress for a meeting at San Francisco, Cal., in the earlier half of October 1911, which will probably include a visit en route to the Grand Cañon. After the close of the San Francisco meeting an excursion to Japan is contemplated, sailing from San Francisco October 17, in the 27,000-ton Pacific Mail Steamship Manchuria, arriving at Yokahama November 3, and returning November 21. The dates are arranged with a view to witnessing the festivities connected with the birthday of the Mikado.

AMERICAN SOCIETY OF CIVIL ENGINEERS

At the bi-monthly meeting of the American Society of Civil Engineers on February 1, George Robert Graham Conway presented his paper on The Water-Works and Sewerage of Monterey. On February 15, Water Purification Plant, Washington, D. C., Results of Operation, by E. D. Hardy, was considered. The meeting of March 1 will be devoted to a paper by Albert R. Raynor, The Pittsburg and Lake Erie Railroad Cantilever Bridge over the Ohio River at Beaver, Pa.

NEW MECHANICAL ENGINEERING LABORATORIES OF UNIVERSITY OF NEBRASKA

The new mechanical engineering laboratories of the University of Nebraska were formally dedicated on January 18, 1911, with impressive ceremonies. The building, which is one of the finest of the university group and has over-all dimensions of 192 by 160 feet, is executed in brown pressed brick with terra cotta trimmings. In addition to the class rooms and offices of the department, it contains the power, fuel testing, wood working, foundry, forging and machine tool laboratories, with a thoroughly modern equipment.

The program of the day included a series of addresses to engineering students in the forenoon, by J. A. L. Waddell of Kansas City, Mo., Bion J. Arnold of Chicago, and M. E. Cooley, Mem.Am.Soc.M.E., Dean of the College of Engineering of the University of Michigan. At noon a luncheon was served by the Men's Faculty Club to the distinguished visitors, at which was announced the gift of three scholarship funds. During the afternoon the building was thrown open to inspection by the public. The formal dedicatory exercises occupied the evening and included brief addresses by Charles S. Allen, President of the Board of Regents, and Samuel Avery, Chancellor of the University. The principal address of the day was delivered by W. F. M. Goss, Mem. Am. Soc. M. E., Dean of the College of Engineering of the University of Illinois, on The College of Engineering as a Feature in General Education. At the close honorary degrees were conferred on B. J. Arnold, M. E. Cooley, Mem.Am.Soc. M.E., and J. A. L. Waddell.

WORK OF THE NATIONAL SOCIETY FOR THE PROMOTION OF INDUSTRIAL EDUCATION

The National Society for the Promotion of Industrial Education has recently issued a pamphlet setting forth the aims and activities of the society and outlining its work for 1911. In a very concise way this pamphlet describes the need for industrial education to meet modern conditions of manufacturing and to enable the United States to compete in the markets of the world, and points out the need for a society especially devoted to the promotion of industrial education for the organized awakening of public interest. The society is now entering the fiftieth year of its existence. Its officers are: President, James P. Munroe, of Boston; Vice-President, Frederick A. Geier, Mem.Am.Soc.M.E., of Cincinnati; Treasurer, Frederic B. Pratt, of Brooklyn; Secretary, Edward H. Reisner, New York.

CANADIAN SOCIETY OF CIVIL ENGINEERS

At the twenty-fifth annual meeting of the Canadian Society of Civil Engineers at Winnipeg, Manitoba, January 24-27, 1911, committee reports on Railway Ties, on Rails, Fastenings, and Tie-Plates, and on other subjects, were received and considered. The address of the retiring president, Col. H. N. Ruttan, Chartering, Location and Construction of Railways, was delivered on Thursday morning. Among the papers presented were a description of the Winnipeg Municipal Power Plant, now under construction, by W. G. Chace; and one upon the Hydro-Electric Development Work of the British Canadian Power Company in the Cobalt District, by A. L. Mudge. The officers elected for the ensuing year are, C. H. Rust, President, and Henry Holgate and C. E. W. Dodwell, Vice-Presidents.

KANSAS ENGINEERING SOCIETY

At the annual meeting of the Kansas Engineering Society held in Topeka, Kansas, January 20 and 21, papers were presented upon the Evolution of Highway Bridge Construction, W. H. Jones; Surveys, J. W. Mavity; First Transportation, J. M. Meade; Stream Pollution and Sewerage, W. C. Hoad; Value of Pure Water, R. E. McDonnel; Foundations, H. S. Tullock; and other subjects of interest.

OHIO ENGINEERING SOCIETY

On January 24-26, the Ohio Engineering Society held its thirty-second annual meeting in Columbus, Ohio. Much time was devoted during the convention to the discussion of the proposed bill recently introduced into the Ohio State Legislature, providing for the registration and examination of civil and mining engineers and surveyors, and a resolution was adopted endorsing the bill. Among the papers presented were, Construction of Bituminous Macadam Roads, Jas. T. Voshell; Road Laws of Ohio, J. C. Wonders; Province of Disinfection, Clyde Potts; Some Features of Design of Filtration Plants, Philip Burgess; and a symposium on Operation of Sewage Purification Works, by Paul Hansen, Wm. H. Dittoe, and R. W. Ferris. The following officers were elected for the ensuing year: President, Hugh K. Lindsay; Vice-President, Frank R. Landor; Secretary-Treasurer, C. J. Knisely.

CONNECTICUT SOCIETY OF CIVIL ENGINEERS

At the twenty-seventh annual meeting of the Connecticut Society of Civil Engineers, held in New London on February 14 and 15, 1911, officers were elected for the ensuing year.

At the afternoon session of the opening day addresses were made by Alfred D. Flinn of the Board of Water Supply of New York, on The Catskill Water Works for New York, and by Herbert M. Knight, formerly with the Sewerage Commission, on Some Features of Baltimore's Ten Million Dollar Sewerage System. Both were illustrated with lantern slides. Wednesday morning was occupied with papers on Testing Water Wheels after Installation, by Chas. M. Allen, Mem.Am.Soc.M.E.; The Relation of the Weather and Forestization to Stream Flow, by Willis L. Moore of the Department of Agriculture; and Actual Yield of a Typical Connecticut Watershed, by R. A. Cairns. Other events of the convention were an excursion to the water works high service pumping station, and an informal dinner.

IOWA ENGINEERING SOCIETY

The twenty-third annual meeting of the Iowa Engineering Society was held on February 15-17, 1911, at Des Moines, Iowa. At the opening session on Wednesday, the Mayor of Des Moines welcomed the society, and a symposium on the Statutory Regulation of Engineering Work was presented by T. R. Warriner, W. G. Raymond, Lafayette Higgins and Anson Marston. Thursday was occupied with two sessions, one in the morning on Drainage, with papers on Tile Drainage, by J. L. Parsons, Results of Experience for Tests of Drain Tile and Sewer Pipe, by Anson Marston, Public Work vs. Politics, by K. C. Gaynor; and another in the afternoon on Sanitary Engineering, with papers on Sewage Purification and Disposal, by Chas. P. Chase, Practical Points in Sewer Construction, by Lowell H. Stone, New Rapid Sand Filters at Iowa City, by J. H. Dunlap, Water Power Development in Iowa, by Arthur H. Ford, and a Review of Investigations of the Recent Typhoid Epidemic in Des Moines, by Lafayette Higgins. On Thursday evening George P. Dieckmann delivered an illustrated lecture on Modern Manufacture of Portland Cement. On Friday, following a business session, a number of papers were presented, among them, Does the Boulevard Lighting System Pay? by Austin Burt; Road Building in Germany, B. Schreiner; Discrepancies in Cement Testing, F. C. Young; and Cement Concrete Street Paving in Mason City, Fred P. Wilson. The afternoon was occupied in a visit to the large new cement factory of the Iowa Portland Cement Company, where cement is manufactured upon a large scale by the most modern methods.

ENGINEERS CLUB OF PHILADELPHIA

The Engineers Club of Philadelphia held its thirty-second annual meeting on February 4, 1911, at 8.30 p. m. The business of the evening included the election of officers, which resulted as follows: President, James Christie, Mem. Am.Soc.M.E.; Vice-President, W. L. Pack; Secretary, W. Purves Taylor; Treasurer, F. H. Stier. The annual address was delivered by the retiring president, Wm. Easby, Jr., on The Beginning of Sanitary Science and the Development of Sewerage and Sewage Disposal.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

The following officers were elected at the annual meeting of the American Society of Heating and Ventilating Engineers, held in the Engineering Societies Building, January 24-26, 1911: President, R. P. Bolton, Mem. Am. Soc.M.E.; 1st Vice-President, John R. Allen; 2d Vice-President, A. B. Franklin; Secretary, W. W. Macon, Jun.Am.Soc.M.E.; Treasurer, U. G. Scollay. This was reported in an incorrect form in The Journal for February.

PERSONALS

J. F. Beecher, has become connected with the Tennessee Coal, Iron & R. R. Co., Birmingham, Ala., in the capacity of checker of the coke oven department. Mr. Beecher was formerly associated with the Indiana Steel Co., Gary, Ind.

Charles O. Churchill has been appointed president and secretary of the Westfield Foundry & Valve Co., Westfield, Mass. He was until recently superintendent of the Georgian Manufacturing Co., Binghamton, N. Y.

F. H. Clark, general superintendent of motive power, Chicago, Burlington & Quincy R. R. Co., Chicago, Ill., has become identified with the Baltimore & Ohio R. R., Baltimore, Md., in a similar capacity.

William Darbee, formerly assistant general manager of the Consolidated Gas, Electric Light & Power Co. of Baltimore, Md., has become connected with the Electric Bond & Share Co., New York.

Geo. T. Frankenberg has accepted a position with the Cambria Steel Co. as general outside foreman of the Cambria Works. Until recently he was connected with the Ralston Steel Car Co., Columbus, O.

W. S. Hazelton has been appointed manager of the Chicago office of the Corrugated Bar Co.

Prof. Frederick R. Hutton, Hon. Secy., Am.Soc.M.E. has been appointed consulting engineer in the Department of Water Supply, Gas and Electricity, New York.

Sherwood F. Jeter has resigned from the position of mechanical engineer for the Bigelow Co., New Haven, Conn., a position he has held for the past five years, to become supervising inspector for the Hartford Steam Boiler Inspection and Insurance Co., Hartford, Conn.

An account of Prof. William Kent's impressions of the engineering features of the Panama Canal has been published in the December 27 issue of the South American Supplement of The Times, London, England.

S. L. G. Knox, recently associated with M. Burr, Jr., & Co., New York, has become consulting engineer of the Hammon Engineering Co., San Francisco, Cal.

Wm. W. Macon, managing editor of The Metal Worker, has been elected secretary of the American Society of Heating and Ventilating Engineers.

W. P. Pressinger, having sold his interest in the Keller Manufacturing Co. of Philadelphia, Pa., has resigned as vice-president to again become manager of the compressor department of the Chicago Pneumatic Tool Co., with headquarters in New York.

Henry B. Seaman, who recently resigned as chief engineer of the Public Service Commission for the first district, New York, has resumed private practice with offices in New York.

Grant B. Shipley, formerly engineer of the mining and timber preserving machinery for the Allis-Chalmers Co., Milwaukee, Wis., is now president of the Pittsburg Wood Preserving Co.

John Vandemoer has become associated with the El Paso Smelting Works, El Paso, Tex. He was formerly identified with the Cia. Metalurgica Nacional, Matehuala, S. L. P., Mexico.

W. H. Whiteside recently resigned from the presidency of the Allis-Chalmers Co., Milwaukee, Wis.

Francis H. Wisewell, formerly of Westinghouse, Church, Kerr & Co. and of the International Heater Co., has been elected vice-president of the Mohawk Valley Heating Co., Utica, N. Y.

ACCESSIONS TO THE LIBRARY

This list includes only accessions to the library of this Society, included in the Engineering Library. Lists of accessions to the libraries of the A.I.E.E. and A.I.M.E. can be secured on request from Calvin W. Rice, Secretary, Am.Soc.M.E.

ACADEMIC AND INDUSTRIAL EFFICIENCY. A report to The Carnegie Foundation for the Advancement of Teaching. By M. L. Cooke. (Bulletin No. 5.) *New York, 1910.* Gift of the author.

AMERICAN BLACKSMITH. Vols. 2, 4, 6, 7. *Buffalo, 1902-1908.*

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. The Journal. Nos. 7–12. July-December, 1910. *New York, 1910.*

AMERICAN WATER WORKS ASSOCIATION. Proceedings of 30th annual convention, 1910. *1910.* Gift of the association.

ART OF AVIATION. By R. W. A. Brewer. *New York, McGraw-Hill Book Co., 1910.* Gift of publishers.

BARGE CANAL BULLETIN. Department of the State Engineer and Surveyor of the State of New York. December 1910. *Albany, 1910.* Gift of New York State Engineer.

CENTRAL FOUNDRY COMPANY. Plan and Agreement of Reorganization. Dated January 3, 1911. *New York, 1911.* Gift of the company.

CONCERNING THE FACTORY MUTUALS AND CERTAIN NEW LEGISLATION. *Providence, R. I., 1910.* Gift of C. W. Rice.

EFFICIENCY AS A BASIS FOR OPERATION AND WAGES. By Harrington Emerson. *New York, Engineering Magazine, 1909.*

ELECTRICITY UNCOVERS A LAW OF EVOLUTION. By George Iles. *1909.* Gift of the author.

GYPSUM AS A FIREPROOF MATERIAL. By H. G. Perring. *Chicago, 1910.* Gift of the author.

HEAT INSTALLATIONS. By W. D. Allen. *Seattle.* Gift of C. W. Rice.

HYDRAULIC TURBINES, THEIR DESIGN AND INSTALLATION. By Viktor Gelpke and A. H. Van Cleve. *New York, McGraw-Hill Book Co., 1911.*

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INTRODUCTION TO THERMODYNAMICS FOR ENGINEERING STUDENTS. By John Mills. *Boston, Ginn & Co., 1910.*

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LOGICAL BASIS FOR VALUATIONS OF INTERURBAN STREET RAILWAYS. By C. G. Young. (Reprint of paper read at the Annual Meeting of the Central Electric Railway Association, January 19, 1911.) Gift of the author.

MANUAL OF MARINE ENGINEERING. By A. E. Seaton. ed. 16. *London, Chas. Griffin & Co., 1907.*

MARINE BOILERS, their Construction and Working, Dealing more especially with Tubulous Boilers, based on the work by L. E. Bertin. Translated and edited by L. S. Robertson. ed. 2. *New York, D. Van Nostrand Co., 1906.*

MOTOR LOAD OF MASSACHUSETTS CENTRAL STATIONS. By W. S. Kelley. (Reprinted from Electrical World, Oct. 6, 1910.) Gift of the author.

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POCKET BOOK OF MECHANICAL ENGINEERING. By C. M. Sames. ed. 4. *Jersey City, N. J., 1911.* Gift of the author.

PRINCIPLES AND DESIGN OF AEROPLANES. By Herbert Chatley. *New York, D. Van Nostrand Co., 1911.*

PROFIT MAKING IN SHOP AND FACTORY MANAGEMENT. By C. U. Carpenter. *New York, Engineering Magazine, 1908.*

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STANDARD SPECIFICATIONS FOR STRUCTURAL STEEL, TIMBER, CONCRETE AND REINFORCED CONCRETE. By J. C. Ostrup. ed. 2. *New York, McGraw-Hill Book Co., 1911.*

STANDARDIZATION OF LOCOMOTIVES IN INDIA. By Cyril Hitchcock. (Read before Meeting of the Local Section of The Institution of Mechanical Engineers, at Calcutta, Nov. 23, 1910.) Gift of the institution.

STEAM TURBINES, THEIR DESIGN AND CONSTRUCTION. By Rankin Kennedy. *New York, Macmillan Co., 1910.*

STREET RAILWAY ASSOCIATION OF THE STATE OF NEW YORK. Report of the 28th annual meeting, 1909–1910. *Kingston, 1910.* Gift of the association.

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EXCHANGES

CANADIAN MINING INSTITUTE. Journal. Vol. 13. 1910. *Montreal, 1911.*

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TRADE CATALOGUES

W. D. ALLEN, *Seattle, Wash.* Heat installations in modern buildings, 11 pp.

ALLIANCE MACHINE CO., *Alliance, O.* Electric cranes, charging machines, punches and shears, 88 pp.

C. L. BARKER, *Norwalk, Conn.* Catalogue J, Barker Motors, 28 pp.

BAUSCH & LOMB OPTICAL CO., *Rochester, N. Y.* Baloptical, model C, for general projection work, 16 pp.

BRETZ CO., *New York.* Ball bearings, 20 pp.; F. &. S. annular ball bearings, 8 pp.; thrust bearings, 3 pp.; annular ball bearings, magneto type, 3 pp.; single annular type ball bearings, 7 pp.; list of automobile makers using F. & S. ball bearings, 3 pp.; price list, 6 pp.; various styles of ball bearings, 116 pp.; German edition of Bretz, F. & S. ball bearings, 176 pp.

BRISTOL CO., *Waterbury, Conn.* Bull. no. 130, Indicating and recording electric pyrometers, 47 pp.

CHICAGO PNEUMATIC TOOL CO., *Chicago, Ill.* Franklin air compressors, 96 pp.

CRANE CO., *New York.* Complete pocket catalogue of standard pressure valves, cocks, fittings, steam supplies, 464 pp.

DUCKER CO., *New York.* Sectional and ready-made Ducker houses, 22 pp.

ELECTRIC CONTROLLER & MFG. CO., *Cleveland, O.* Common Sense, December 1910.

CHARLES ENGELHARD, *New York.* Heraeus-LeChatelier pyrometer, 83 pp.; guide to installation of pyrometer, 17 pp.; electrically-heated furnace for high temperatures, 10 pp.; apparatus made of melted rock crystal, 3 pp.; pure silica ware, 6 pp.; Heraeus electric muffle furnace, 8 pp.

A. FREUNDLICH, *Düsseldorf, Germany.* Ammunition cooling plant on board warships, 8 pp.

GANDY BELT CO., *Baltimore, Md.* Belts and belting, 6 pp.

GENERAL ELECTRIC CO., *Schenectady. N. Y.* Illuminous and flame arcs *vs.* open and enclosed carbon arcs for street illumination, 28 pp. Bull. no. 4685, Belt-driven alternators, 11 pp.; Bull. no. 4804, Direct-connected generating sets, 11 pp.; Bull. no. 4810, Portable and stationary air compressors, 7 pp.

HESS-BRIGHT MFG. CO., *Philadelphia, Pa.,* Catalogue of ball and roller bearings, 64 pp.

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H. W. JOHNS-MANVILLE CO., *Cleveland, O.* J-M Roofing Salesman, January 1911, 8 pp.

LAGONDA MFG. CO., *Springfield, O.* Turbine boiler tube cleaners, 48 pp.

F. E. MYERS & BROS., *Ashland, O.* Catalogue no. 49, Pumps, hay unloading tools, barn door hangers, agricultural implements, 404 pp.

PHILADELPHIA GEAR WORKS, *Philadelphia, Pa.* Catalogue, 76 pp.

B. F. STURTEVANT CO., *Hyde Park, Mass.* Fuel economizers and air heaters, 40 pp.

TECHNICAL DATA & APPLIANCE CO., *Chicago, Ill.* Data, November 1910, 62 pp.

UNITED ENGINEERING SOCIETY

DIRECTORY OF DIRECTORS IN THE CITY OF NEW YORK. 1909–1910. *New York, Audit Company of New York, 1910.*

OKLAHOMA GEOLOGICAL SURVEY. Director's Biennial Report to the Governor, 1910. (Bulletin no. 6.) *Norman, 1910.*

WILLING'S PRESS GUIDE, 1911. *London, 1911.*

EMPLOYMENT BULLETIN

The Society has always considered it a special obligation and pleasant duty to be the medium of securing better positions for its members. The Secretary gives this his personal attention and is most anxious to receive requests both for positions and for men available. Notices are not repeated except upon special request. Copy for notices in this Bulletin should be received before the 12th of the month. The list of men available is made up of members of the Society and these are on file, with the names of other good men not members of the Society, who are capable of filling responsible positions. Information will be sent upon application.

POSITIONS AVAILABLE

071 Superintendent of machine shop, building high speed automatic engines experience in handling workmen on the premium or bonus systems. Should have had experience in designing jigs for duplicate work and reducing shop costs. Technical education necessary. Location central Illinois.

072 A leading high speed engine builder is in need of an experienced superintendent and designing engineer; must be familiar with best modern shop practice, and have had previous experience in steam engine design. Salary not so much of a consideration as ability. Do not wish to correspond with anyone not receiving a good salary now. Location Pennsylvania.

073 Inspector wanted by power company; applicant should be a graduate of technical school with three or more years experience in drafting rooms and shops of railroads or concerns manufacturing heavy machinery. Location New York State.

074 Member desires to join consulting engineer who either from age or other reasons would wish to take partner into his employ or have associated with him. Compensation secondary consideration to prospects. Location Philadelphia or New York preferred.

075 First class man to represent firm in connection with agents in the middle west. College graduate, thirty years of age or over, thorough knowledge of machine shop practice and machine tools. Business will be to go into machine shops and recommend proper machines and equipment for increasing output.

076 Works manager competent to direct design and construction of apparatus involving small parts. Must be competent to manage two large factories, separated some distance from each other. Salary $6000 to $10,000.

077 Graduate M. E., as assistant superintendent in manufactory of creamery and dairy apparatus and general woodwork, employing upwards of

100 men. Must be quick to detect imperfections, tactful and patient with men, an organizer; assist in matters pertaining to introduction of modern methods of scientific factory management and cost-keeping. Location Vermont. Salary to begin, $1000 per year.

078 Engineering salesman; young man, technical graduate preferred, to sell well-known line of special machinery. State experience and salary expected.

MEN AVAILABLE

172 Mechanical and electrical engineer, six years experience in teaching engineering at state universities, two years head of department, last four years in practical professional lines, desires communication with educational institution wishing the services of a high grade man. Prefers to teach in the line of machine design or electrical engineering.

173 Technical graduate, mechanical and electrical engineering, married, eight years experience, in large mill on automatic machinery construction, contracting and charge of drafting room, desires position in Massachusetts. Best of references. Understands latest methods of mill systems.

174 Mechanical engineer with several years experience in engine works; past ten years head of strong engineering college in prominent university desires a change. Responsible teaching position preferred.

175 Junior member, at present employed, graduate in mechanical engineering, taught machine design one year; one year technical drafting; desires position as assistant to works superintendent or industrial engineer. Salary, $1400.

176 Manager for company, 25 years in East, in machine tool line, desires position as sales manager. Extensive acquaintance and experience in selling machinery throughout United States and Canada.

177 Graduate mechanical engineer, Mass. Inst. Tech.; three years teaching engineering subjects; two years in practical work in New York. At present engaged in research work for degree of M.M.E. Desires position as professor in steam engineering.

178 Sales engineer, would consider position where knowledge of machinery and mill supply trade of the United States and Canada is essential; seven years varied engineering experience; six years in selling end. Experience in correspondence and design of selling contracts.

CHANGES IN MEMBERSHIP

CHANGES OF ADDRESS

ADAMS, Edward T. (1899), Pres., Wisconsin Eng. Co., Corliss, and 539 Terrace Ave., Milwaukee, Wis.

BAXTER, Burke Morgan (Junior, 1908), Mech. Engr. with H. B. Prather, Cons. Engr., 662 Rockefeller Bldg., and *for mail*, 1803 Wilton Road, Cleveland, O.

BEECHER, J. F. (Associate, 1908), Checker, Coke Oven Dept., Tennessee Coal, Iron & R. R. Co., and *for mail*, 2025 Fifth Ave., Birmingham, Ala.

BIRDSEY, Charles Robt. (Associate, 1907), Ch. Engr., U. S. Gypsum Co., 200 Monroe St., and *for mail*, 503 S. Central Park Ave., Chicago, Ill.

CAMERON, Barton H. (1903), Pres., Cameron Stove Co., Box 635, and *for mail*, 1804 Hanover Ave., Richmond, Va.

CASE, Albert H. (Junior, 1903), Supt., Santa Fé Gold & Copper Min. Co., San Pedro, New Mex., and *for mail*, P. O. Box 164, Philipsburg, Pa.

CHURCHILL, Charles O. (1906), Pres. and Secy., Westfield Fdy. & Valve Co., Westfield, Mass.

CLARK, Frank Henry (1910), Genl. Supt., M. P., B. & O. R. R., Baltimore, Md.

COLLINS, B. R. T. (1891; 1901), 19 Congress St., Boston, Mass.

COX, Frederick W. (1908), present address unknown.

CREELMAN, Frank (1894), 447 W. 23d St., New York, N. Y.

DARBEE, William (Junior, 1900), Elec. Bond & Share Co., 71 Broadway, New York, N. Y.

DONNELLY, William T. (1903), Cons. Engr., 17 Battery Pl., New York, N.Y.

FERGUSSON, Henry A. (1902), Cons. Engr., and Genl. Mgr., Steel Roof Truss Co., Valley Park, and 505 Lockwood Ave., Webster, Mo.

FRANKENBERG, George T. (Associate, 1907), Genl. Outside Foreman, The Cambria Steel Co., and *for mail*, 522 Second Ave., Westmont, Johnstown, Pa.

GILLAN, Howard A. (Junior, 1907), Mech. Engrg. Dept., N. Y. C. & H. R. R. R. Co., 42d St., and *for mail*, 660 W. 179th St., New York, N. Y.

GRAY, William Emery (1907), Genl. Sales Mgr., The Enameled Pipe & Engrg. Co., Elyria, O.

HAZELTON, WILLIAM S. (1909), Mgr., Chicago Office, Corrugated Bar Co., 1825 Commer. Natl. Bank Bldg., Chicago, Ill.

HENRY, Geo. J., Jr. (1901), Ch. Engr., Pelton Water Wheel Co., 19th and Harrison Sts., and 3999 Clay St., San Francisco, Cal.

HERRESHOFF, J. B. Francis (1894), V. P., Nichols Copper Co., Cons. Engr., Genl. Chem. Co., 25 Broad St., and *for mail*, 620 West End Ave., New York, N. Y.

HERRON, James H. (1897; 1905), Cons. Engr., Engrs. Bldg., and Fairmount Blvd., Shaker Hgts., Cleveland, O.

HOGUE, Oliver D. (1909), Mgr., Power Pump Dept., The Goulds Mfg. Co., 58 Pearl St., Boston, Mass.

HORNE, H. Field (Junior, 1909), Asst. Supt., M. W. Kellogg Co., 117 West Side Ave., Jersey City, N. J., and *for mail*, Mohegan, N. Y.

INGERSOLL, Geo. T. (1903), Worcester, Otsego Co., N. Y.

JETER, Sherwood F. (1909), Supv. Inspr., Hartford Steam Boiler Inspc. & Ins. Co., Hartford, Conn.

JETT, Carter C. (Junior, 1902), 1499 E. 55th St., Cleveland, O.

KENYON, Alfred Lewis (1904), Tallulah Falls, Ga.

KNISKERN, W. H. (Junior, 1905), Secy., Freeborn Engrg. & Constr. Co., 605–615 Scarritt Bldg., and 651 W. 39th St., Kansas City, Mo.

KNOX, S. L. Griswold (1892; 1901), Cons. Engr., Hammon Engrg. Co., Alaska Commer. Bldg., San Francisco, Cal.

MAROT, Edward H. (Junior, 1903), Dist. Sales Mgr., Hyatt Roller Bearing Co., and *for mail*, Genl. Delivery, Newark, N. J.

PALMER, Cortlandt E. (1895), U. S. Express Bldg., 2 Rector St., New York, N. Y.

PARSONS, Willard P. (1884), Secy., Cohoes Co., and 69 Front St., Cohoes, N. Y.

PAUL, John Wallace (1895; 1896), P. O. Box 85, Groton, N. Y.

PRICE, Norman I. (Junior, 1902), Union Bank Chambers, Pitt St., Sydney, Australia.

RENOLD, Charles Garonne (Junior, 1906), Dir., Hans Renold, Ltd., Progress Wks., and 53 Heaton Rd., Withington, Manchester, England.

ROGERS, Robert W. (Junior, 1908), Office of Genl. Mech. Supt., Erie R. R., 50 Church St., New York, N. Y., and *for mail*, 386 Washington Ave., North Newark, N. J.

SARENGAPANI, T. S. (Junior, 1903), Head Draftsman, Kistna Reservoir Project, Madras, India.

SCOTT, Clarence N. (1902), The Texas Co., Houston, Tex.

SHAW, James C. (1909), Engr. and Tech. Adviser, Kawasaki Dockyard Co., Ltd., and 2 Nakayamale Dori 3 Chome, Kobe, Japan.

SMEAD, William H. (Junior, 1906), Engr., West. Htg. and Power Piping Dept., Genl. Fire Extinguisher Co., Warren, O.

SMITH, Ernest L. (1901; 1908), 870 Woodward Ave., Detroit, Mich.

STANTON, Francis A. O'C. (Junior, 1909), City Engr., 1104 Bloomfield St., Hoboken, N. J., and 2 Rector St., New York, N. Y.

TABOR, Leroy (1909), The Tabor Mfg. Co., 18th and Hamilton Sts., Philadelphia, Pa.

THORN, Charles Norman (Associate, 1910), Pur. Agt. and Mech. Engr., Hugh Kelly & Co., 81 Wall St., New York, N. Y.

TURNER, Charles P. (Associate, 1907), 610 Chapel St., Schenectady, N. Y.

VANDEMOER, John (Associate, 1904), El Paso Smelting Wks., El Paso, Tex.

VOSE, Fred Hale (1906; 1910), Mech. Engrg. Dept., Case Sch. of Applied Science, and *for mail*, 9904 Newton Ave., Cleveland, O.

WEHNER, Lewis (1901; 1907), First Asst. Engr., The Bucyrus Co., South Milwaukee, and *for mail*, 508 Cudahy Apts., Juneau Pl. and Mason St., Milwaukee, Wis.

WHITTEMORE, John R. (1902), 230 Madeline Drive, Pasadena, Cal.
WILEY, James M. (Junior, 1909), Holly Sugar Co., Huntingdon Beach, Cal.
WISEWELL, Francis H., Jr. (Junior, 1905), V. P., Mohawk Valley Htg. Co., 22 Broad St., Utica, N. Y.

NEW MEMBERS

ALLISON, John Franklin (Junior, 1910), Instr. in Forge and Fdy., Clemson Agri. College, Clemson College, S. C.
CARR, Jesse Douglas (1910), 2506 W. 8th St., Los Angeles, Cal.
DAHLSTRAND, Hans (1910), Mech. Engr., Steam Turbine Engrg. Dept., Allis-Chalmers Co., and *for mail*, 3917 Galena St., Milwaukee, Wis.
HAAS, Lucian L. (Junior, 1910), Ch. Tool Designer, E. R. Thomas Motor Co., and *for mail*, 38 Best St., Buffalo, N. Y.
JONES, Reid (Junior, 1910,) Mech. Engr., San Antonio Water Supply Co., San Antonio, Tex.
ORR, John (1909), Prof. of Engrg., S. A. Sch. of Mines and Tech., P. O. Box 1176, Johannesburg, Transvaal, S. A.
SHARP, John Thomas, Jr. (Junior, 1910), Supt., Canton Elec., Light & Water Wks., Canton, Miss.
SPILLMAN, Harry St. Clair (Junior, 1910), Supt. of Bldgs., Constr. Wk. and Power Equip., Hudson Motor Car Co., and *for mail*, 1465 Brush St., Detroit, Mich.
VARNES, Samuel K. (Junior, 1910), Exper. Engr., Pa. Steel Co., Steelton, and *for mail*, 226 Maclay St., Harrisburg, Pa.
WESTLAKE, Charles Thomas (1910), Ch. Mech. Engr., Commonwealth Steel Co., 1629 Pierce Bldg., St. Louis, Mo.

DEATHS

ALBERGER, Louis R., January 31, 1911.
CORBETT, William H., February 20, 1911.
EDSON, Jarvis B., January 26, 1911.
FREEMAN, Stuart, February 2, 1911.
MORGAN, Charles Hill, January 10, 1911.
NORBOM, John O., January 20, 1911.
SEAVER, John Wright, January 14, 1911.

GAS POWER SECTION

CHANGES OF ADDRESS

ADAMS, Edward T. (1909), Mem.Am.Soc.M.E.
HAYES, Frank A. (Affiliate, 1909), 272 Lafayette Ave., Passaic, N. J.
PAUL, John Wallace (1909), Mem. Am.Soc.M.E.
SUTER, John (Affiliate, 1909), Pittsburg Plate Glass Co., Kokomo, Ind.

NEW MEMBERS

CRANKSHAW, Robert Newton (Affiliate, 1910), Ch. Draftsman, Power Dept., Bethlehem Steel Co., and *for mail*, 220 Wall St., Bethlehem, Pa.
SHATTUCK, John David (Affiliate, 1910,) Gen. Supt., Am. Gas Co., Chester, Pa.

STUDENT BRANCHES

CHANGES OF ADDRESS

BESS, Earl (Student, 1910,) 245 N. D. St., Hamilton, O.
BRUCE, A. C. (Student, 1910), 1301 Dearborn Ave., Chicago, Ill.
CRAIG, W. D. (Student, 1910), 68 Centre St., Woodbury, N. J.
CUMMINGS, C. G. (Student, 1910), 66 High St., Medford, Mass.
ESTEP, Albert B. (Student, 1910), care S. H. Frye, Carnegie, Pa.
GLICK, G. A. (Student, 1910), care G. A. Lowe Co., Ogden, Utah.
GREEN, J. B. (Student, 1910), Sellersburg, Ind.
GRIFFITHS, F. H. (Student, 1909), 3327 Armour Ave., Chicago, Ill.
HERBERT, E. H. (Student, 1909), Doak Gas Eng. Co., 4th and Madison Sts., Oakland, Cal.
LOCKARD, J. P. (Student, 1909), Y. M. C. A. Bldg., Lynn, Mass.
MARGARIDA, Manuel (Student, 1910), 478 Main Bldg., State College, Pa.
MARSH, Karl (Student, 1910), Dominion Iron & Steel Co., Sydney, N. S., Canada.
MATTHAI, A. D. (Student, 1910), 9 Buckingham Rd., Brooklyn, N. Y.
MOORE, R. S. (Student, 1910), 430 Charter St., Madison, Wis.
MUELLER, B. H. (Student, 1910), 1015 W. Johnson St., Madison, Wis.
OGILVIE, George E. (Student, 1910), Genl. Delivery, Lynchburg, Va.
PARSONS, Harry N. (Student, 1909), 48 W. 34th St., Chicago, Ill.
RAHN, Robert M. (Student, 1910), 327 McAllister Hall, State College, Pa.
RUGG, D. M. (Student, 1909), Indiana Steel Co., Gary, Ind.
SHEARER, W. H. (Student, 1910), 127 Third St., Troy, N. Y.
SWIGGETT, C. A. (Student, 1909), 1014 S. Main St., Wichita, Kan.
TAYLOR, John R. (Student, 1910), Blairsville, Pa.
WHEDBEE, Edgar (Student, 1909), 356 Schermerhorn St., Brooklyn, N. Y.
WIEST, Howard N. (Student, 1910), 281 Pleasant St., Milwaukee, Wis.

NEW MEMBERS

ARMOUR INSTITUTE OF TECHNOLOGY

AMBROSE, R. B. (Student, 1911), 6124 Woodlawn Ave., Chicago, Ill.
RUEF, J. (Student, 1911), 721 W. 61st St., Chicago, Ill.
WONG, Yuk (Student, 1911), 3546 Wentworth Ave., Chicago, Ill.

COLUMBIA UNIVERSITY

STONE, E. W. (Student, 1911), 1128 Bedford Ave., Brooklyn, N. Y.

CORNELL UNIVERSITY

COFFIN, W. C. F. (Student, 1911), 116 Oak Ave., Ithaca, N. Y.
CONSTAM, A. F. (Student, 1911), 205 Williams St., Ithaca, N. Y.
HEYWOOD, F. C. (Student, 1911), 110 Osmun Pl., Ithaca, N. Y.
MORSE, D. F. (Student, 1911), 102 Highland Pl., Ithaca, N. Y.
RITSCHARD, V. (Student, 1911), 116 Oak Ave., Ithaca, N. Y.
SMITH, D. F. (Student, 1911), 411 Dryden Rd., Ithaca, N. Y.
ZINK, R. E. (Student, 1911), Hillcrest, Ithaca, N. Y.

LELAND STANFORD JUNIOR UNIVERSITY

CAMPBELL, C. P. (Student, 1911), Stanford Univ., Cal.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

DOBLE, R. N. (Student, 1911), 24 South St., Quincy, Mass.
SEATON, Roy A. (Student, 1911), 198 W. Brookline St., Boston, Mass.
SEELEY, N. S. (Student, 1911), 44, The Fenway, Boston, Mass.

PENNSYLVANIA STATE COLLEGE

GROMAN, F. C. (Student, 1911), Alpha Kappa Delta House, State College, Pa.
JONES, H. H. (Student, 1911) 229 W. Beaver Ave., State College, Pa.
KINNEY, J. A. (Student, 1911), 224 Allen St., State College, Pa.
MASON. M. M. (Student, 1911), 418 Main Bldg., State College, Pa.
RHOADS, R. L. (Student, 1911), Phi Tau House, State College, Pa.
ROBINSON, C. A. (Student, 1911), 337 McAllister Hall, State College, Pa.
SCHAEFFER, H. M. (Student, 1911), 237 McAllister Hall, State College, Pa.
WILLIAMS, A. S. (Student, 1911), 352 McAllister Hall, State College, Pa.

POLYTECHNIC INSTITUTE OF BROOKLYN

ENNIS, Roy C. (Student, 1911), Poly. Inst. of Brooklyn, Brooklyn, N. Y.
KOPF, Chas. J. (Student, 1911), Rm. 1061, 200 Fifth Ave., New York, N. Y.

STATE UNIVERSITY OF KENTUCKY

BOYD, J. A. (Student, 1911), 605 S. Limestone St., Lexington, Ky.
CAMPBELL, John (Student, 1911), Ky. State Univ. Dormitory, Lexington, Ky.
CASSIDY, P. R. (Student, 1911), 630 W. High St., Lexington, Ky.
CLEVELAND, M. A. (Student, 1911), Ky. State Univ. Dormitory, Lexington, Ky.
DANIEL, C. E. (Student, 1911), 427 S. Upper St., Lexington, Ky.
DAY, O. L. (Student, 1911), Sta. 4, Box 642, Lexington, Ky.
DOUGLAS, E. T. (Student, 1911), Sta. 4, Box 696, Lexington, Ky.
DOWNING, V. L. (Student, 1911), 158 N. Ashland Ave., Lexington, Ky.
DUNCAN, W. C. (Student, 1911), Ky. State Univ. Dormitory, Lexington, Ky.
EBBERT, S. C. (Student, 1911), 136 E. Maxwell St., Lexington, Ky.

FITZPATRICK, J. J. (Student, 1911), Ky. State Univ. Dormitory, Lexington, Ky.
FOSTER, J. M. (Student, 1911), 315 E. Maxwell St., Lexington, Ky.
HASWELL, A. B. (Student, 1911), Ky. State Univ. Dormitory, Lexington, Ky.
LURTEY, W. A. (Student, 1911), Sta. 4, Box 642, Lexington, Ky.
MILES, F. T. (Student, 1911), Sta. 4, Box 651, Lexington, Ky.
MILLS, G. C. (Student, 1911), Ky. State Univ. Dormitory, Lexington, Ky.
MOORE, H. Lee (Student, 1911), 315 E. Maxwell St., Lexington, Ky.
NEEDY, J. A. (Student, 1911), Sta. 4, Box 711, Lexington, Ky.
PHISTER, J. B. (Student, 1911), Ky. State Univ. Dormitory, Lexington, Ky.
SANDERS, J. B. (Student, 1911), 213 Clay Ave., Lexington, Ky.
SHANKLIN, G. B. (Student, 1911), cor. Maxwell and S. Broadway, Lexington, Ky.
SLADE, Theodore (Student, 1911), 507 N. Broadway, Lexington, Ky.
SMARR, B. M. (Student, 1911), 136 E. Maxwell St., Lexington, Ky.
STEVENSON, W. W. (Student, 1911), 605 S. Limestone St., Lexington, Ky.
WEBB, R. S. (Student, 1911), 353 S. Mill St., Lexington, Ky.

STEVENS INSTITUTE OF TECHNOLOGY

SPILLMAN, Thomas B. (Student, 1911), Stevens Inst. of Tech., Hoboken, N. J.

UNIVERSITY OF ILLINOIS

FAUST, P. A. (Student, 1911), 934 W. Illinois St., Urbana, Ih.

UNIVERSITY OF WISCONSIN

WILSON, H. A. (Student, 1911), 1412 63d Pl., Chicago, Ill.
WOOD, L. A. (Student, 1911), 604 State St., Madison, Wis.

YALE UNIVERSITY

BRISTOL, R. W. (Student, 1911), 112 Sheff. Vanderbilt, New Haven, Conn.
FERGERSON, F. A. (Student, 1911), 152 Sheff. Vanderbilt, New Haven,Conn.
FISHER, R. F. (Student, 1911), 96 Wall St., New Haven, Conn.
HILL, B. W. (Student, 1911), 151 Sheff. Vanderbilt, New Haven, Conn.

COMING MEETINGS

March–April

Advance notices of annual and semi-annual meetings of engineering societies are regularly published under this heading and secretaries or members of societies whose meetings are of interest to engineers are invited to send such notices for publication. They should be in the editor's hands by the 15th of the month preceding the meeting. When the titles of papers read at monthly meetings are furnished they will also be published.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

March 10, monthly meeting, 29 W. 39th St., New York. Secy., R. W. Pope.

AMERICAN RAILWAY ENGINEERING AND MAINTENANCE OF WAY ASSOCIATION

March 21–23, annual convention, Congress Hotel, Chicago, Ill. Secy., E. H. Fritch, 962 Monadnock.

AMERICAN SOCIETY OF CIVIL ENGINEERS

March 1, 15, bi-monthly meetings, 220 W. 57th St., New York. Secy., C. W. Hunt.

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Monthly meetings: March 14, 29 W. 39th St., New York; March 17, Boston, Mass. Spring Meeting, May 30–June 2, Pittsburg, Pa. Secy., C. W. Rice, 29 W. 39th St., New York.

AMERICAN SOCIETY OF RAILROAD SUPERINTENDENTS

March 22, spring meeting, Great Northern Hotel, Chicago, Ill. Secy., O. G. Fetter, Carew Bldg., Cincinnati, O.

BOSTON SOCIETY OF CIVIL ENGINEERS

March 15, annual meeting, Boston City Club, Boston, Mass. Secy., S. Everett Tinkham, 715 Tremont Bldg.

CANADIAN CEMENT AND CONCRETE ASSOCIATION

March 7–9, annual convention, Toronto, Ont., Can. Secy., W. Snath, 57 Adelaide St., E.

CANADIAN MINING INSTITUTE

March 2–4, annual meeting, Quebec, Canada. Secy., H. Mortimer-Lamb, Rms. 3–4 Windsor Hotel, Montreal.

ENGINEERING SOCIETY OF WISCONSIN

March 1–3, annual meeting, Madison, Wis. Secy., W. G. Kirchoffer, Vroman Bldg.

NATIONAL ASSOCIATION OF COTTON MANUFACTURERS

April 12–13, annual meeting, Huntington Hall, Mass. Inst. of Tech., Boston, Mass. Secy., C. J. H. Woodbury, Mem.Am.Soc.M.E., Rm. 501 International Trust Bldg.

NATIONAL METAL TRADES ASSOCIATION

April 12–13, annual convention, Hotel Astor, New York. Comr., Robt. Wuest, New England Bldg., Cleveland, O.

NEW ENGLAND RAILROAD CLUB

March 14, annual meeting, Copley Square Hotel, Boston, Mass. Subject for discussion: Master Car Builders' Rules for Interchange. Secy., Geo. H. Frazer, 10 Oliver St.

NEW ENGLAND STREET RAILWAY CLUB

March 23, annual meeting, Boston, Mass. Secy., John J. Lane, 12 Pearl St.

NORTHWESTERN CEMENT PRODUCTS ASSOCIATION

February 28-March 1, annual convention, Minneapolis, Minn. Secy., Harvey B. Smith, 834 Security Bank Bldg.

RAILWAY SIGNAL ASSOCIATION

March 20, Stated Meeting, Congress Hotel, Chicago, Ill. Paper: Alternating Current Signaling. Secy., C. C. Rosenberg, Bethlehem, Pa.

ROME MUNICIPAL GAS COMPANY

April 19–21, annual meeting, Montgomery, Ala. Pres., James Ferrier, Rome, Ga.

TORONTO CEMENT SHOW

March 6–11. Under the auspices of the Canadian Cement and Concrete Association. Secy., W. Snath, 57 Adelaide St., E., Toronto, Ont., Can.

MEETINGS IN THE ENGINEERING SOCIETIES BUILDING

Date	Society	Secretary	Time
March			
2	Blue Room Engineering Society	W. D. Sprague	8.15 p.m.
9	Illuminating Engineering Society	P. S. Millar	8.15 p.m.
10	American Institute Electrical Engineers	R. W. Pope	8.15 p.m.
14	American Society Mechanical Engineers	C. W Rice	8.15 p.m.
17	New York Railroad Club	H. D. Vought	8.15 p.m.
21	New York Telephone Society	T. H. Lawrence	8.15 p.m.
22	Municipal Engineers of New York	C. D. Pollock	8.15 p.m.
April			
6	Blue Room Engineering Society	W. D. Sprague	8.00 p.m.
11	American Society Mechanical Engineers	C. W. Rice	8.15 p.m.
13	Illuminating Engineering Society	P. S. Millar	8.00 p.m.
13	Institute of Operating Engineers	M. W. Rice	8.00 p.m.
14	American Institute Electrical Engineers	R. W. Pope	8.15 p.m.
18	New York Telephone Society	T. H. Lawrence	8.15 p.m.
21	New York Railroad Club	H. D. Vought	8.15 p.m.
24	National Isolated Power Plant Association	E. Fieux	8.00 p.m.
26	Municipal Engineers of New York	C. D. Pollock	8.15 p.m.

CURRENT BOOKS

STEAM TURBINES: THEIR DESIGN AND CONSTRUCTION. By Rankin Kennedy. *New York, The Macmillan Co., 1910.* Cloth 12mo, 104 pp., illustrated. Price $1.25 net.

Contents: Theoretical, Mechanical and Physical; Elementary Turbines; Turbine Wheels in Series; Calculating the Principal Dimensions: The Construction of Turbine Wheels.

AN INTRODUCTION TO THERMODYNAMICS FOR ENGINEERING STUDENTS. By John Mills. *New York, Ginn & Co.* Cloth 8vo., 136 pp.

Contents: Fundamental Concepts and Laws; Gases; Water and its Saturated Vapor; Superheated Steam; Flow of Steam and Gases; Miscellaneous Problems.

HYDRAULIC TURBINES, THEIR DESIGN AND INSTALLATION. By Viktor Gelpke and A. H. Van Cleve. *New York, McGraw-Hill Book Co., 1911.* Cloth 8vo, 293 pp., illustrated. Price $4 net.

Contents: Turbines and their Accessories; Turbine Design; Notable Turbine Installations.

A POCKET BOOK OF MECHANICAL ENGINEERING FOR ENGINEERS AND STUDENTS. By Charles M. Sames. *Jersey City, N. J., Charles M. Sames, 1911.* Morocco, pocket book size, 218 pages.

Contents: Mathematics, Chemical Data; Materials, The Strength of Materials, Structures, and Machine Parts; Energy and the Transmission of Power; Heat and the Steam Engine; Hydraulics and Hydraulic Machinery; Shop Data; Electrotechnics; Appendices.

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1911

On a Standard Tonnage Basis for Refrigeration

D. S. Jacobus — G. T. Voorhees
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Fred J. Miller (1)
Jesse M. Smith (2)
Chas. Wallace Hunt (3)

On National Fire Protection Association

John R. Freeman
Ira H. Woolson

On Joint Committee on Engineering Education

Alex. C. Humphreys
F. W. Taylor

On Advisory Board National Conservation Commission

Geo. F. Swain
John R. Freeman
Chas. T. Main

On Council of American Association for the Advancement of Science

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Fred J. Miller

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University of Kansas, Lawrence, Kan.	March 9	P. F. Walker	W. H. Judy	M. C. Conley
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Mass. Inst. of Tech., Boston, Mass.	November 9	Gaetano Lanza	Morell Mackenzie	Foster Russell
Univ. of Cincinnati, Cincinnati, O.	November 9	J. T. Faig	H. B. Cook	C. J. Malone
Univ. of Wisconsin, Madison, Wis.	November 9	C. C. Thomas	A. MacArthur	A. A. Wegner
Univ. of Missouri, Columbia, Mo.	December 7	H. Wade Hibbard	F. T. Kennedy	Osmer N. Edgar
Univ. of Nebraska, Lincolr, Neb.	December 7	C. R. Richards	W. J. Wholenberg	W. H. Burleigh
	1910			
Univ. of Maine, Orono, Me.	February 8	Arthur C. Jewett	A. H. Blaisdell	W. B. Emerson
Univ. of Arkansas, Fayetteville, Ark.	April 12	B. N. Wilson	W. Q. Williams	H. W. Barton
Yale University, New Haven, Conn.	October 11	L. P. Breckenridge	ClaytonDuBosque	W. Roy Manny
Rensselaer Poly. Inst., Troy, N. Y.	December 9	A. M. Greene, Jr.	G. K. Palsgrove	H. J. Parthesius
	1911			
State Univ. of Ky., Lexington, Ky.	January 10	F. P. Anderson	G. C. Mills	H. L. Moore
Ohio State University, Columbus, O.	January 10	W. T. Magruder	H. A. Shuler	H. M. Bone